Invasive Species, Agriculture and Trade: Case Studies from the NAFTA Context

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Executive Summary

Invasions by plants, animals, and pathogens into non-native environments pose one of the most significant, but least addressed, international threats to biodiversity, both within natural ecosystems and agricultural settings. For agriculture, one recent study estimates that 40% of all insect damage to crops in the U.S. is attributable to non-indigenous species (Pimentel et al. 2000). The impacts from and costs of invasive species can be divided broadly into six categories: crop losses, rangeland value decline, water resource depletion, livestock disease, genetic contamination, and management and eradication costs

While impacts of invasive alien species are primarily local and national, the root causes of their spread are regional and international – driven primarily by global trade, transport and tourism. An analysis of the role of trade in facilitating alien invasive species' impacts to agriculture in North America reveals that regional trade primarily exacerbates impacts of global trade. In other words, trade among NAFTA countries primarily spreads alien invasive species that have been introduced as a result of trade of NAFTA countries with non-NAFTA countries. Many fewer examples exist of regional trade facilitating introduction and establishment of an alien invasive species in a NAFTA country of a species native to another. Most significantly, since NAFTA, regional and global trade has grown significantly, but capacity to inspect for alien invasive species has remained constant – approximately 2% of goods are inspected. As a result, the potential for introduction of alien invasive species via trade has increased significantly.

An examination of case studies of significant alien invasive species and their primary pathways, including Asian Long-horned Beetle *Anoplophora glabripennis* and solid wood packing materials (SWPM), Plum Pox Virus and nursery stock, and genetically modified maize, provides examples of impacts and a glimpse into the adequacy of existing regulatory mechanisms for facing the challenges posed by increased trade. We determine that these pathways pose significant threats to agriculture in North America. Despite some success in preventing impacts, several additional measures are necessary.

We recommend many changes specific to these significant pathways and for broader application. Generally, we recommend that, in addition to existing efforts to exchange information and ideas, NAFTA countries (1) develop a North American strategy to address alien invasive species concerns, including the need to build technical and institutional capacities; (2) recognize costs associated with introductions via trade of alien invasive species and shift focus from increasing trade while dealing with invasives to addressing invasives while allowing trade; (3) minimize dependence on inspections by, for example, ensuring that those responsible for the movement of invasive species are motivated to reduce risks they pose of introduction of invasive alien species; (4) institute additional measures to prevent introduction and establishment of alien invasive species, including, for example, requiring documentation of country of origin of specific materials, mandating use of materials other than SWPM, etc.; (5) encourage involvement of regional organizations in development of regional and international standards; (6) ensure that existing and future bilateral and regional free trade agreements provide sufficient leeway to develop sanitary, phytosanitary and zoosanitary measures necessary to prevent the introduction of invasive species, including through the use of a pathway approach.

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1.0 INTRODUCTION

Invasions by plants, animals, and pathogens into non-native environments pose one of the most significant, but least addressed, international threats to biodiversity both within natural ecosystems and agricultural settings. The impacts of invasive alien species[1] on terrestrial and aquatic ecosystems are second only to habitat destruction as a cause of biodiversity loss. For agriculture, one recent study estimates that 40% of all insect damage to crops in the U.S. is attributable to alien species (Pimentel et al. 2000). While impacts of invasive alien species are primarily local and national, the root causes of their spread are regional and international. Invasive alien species introductions are driven primarily by global trade, transport and tourism. Given the shared ecosystems and relative lack of physical barriers in North America to the spread of invasive species, Canada, Mexico and the U.S. must coordinate and support approaches to address introductions of invasive species that occur through trade.

Examination of the relation between invasive alien species and trade under the North American Free Trade Agreement (NAFTA) entails two levels of analysis:

1. analysis at an intra-continental level, considering introductions that have occurred as a result of trade among Canada, Mexico and the U.S.; and
2. analysis at an inter-continental level, considering introductions that have occurred as a result of trade of NAFTA countries with non-NAFTA countries.

While the range of factors involved in comparing these two levels is complex, available data indicates that the second level – unintentional introduction of exotic species from non-NAFTA countries – currently is the greater threat. Intra-continental trade may introduce a species native to one NAFTA country to another NAFTA country in which the species is not native and may become invasive. Data indicate however, that this scenario of how invasive alien species are introduced in North America is occurring much less frequently than the introduction of invasive alien species into North America through trade with non-NAFTA countries. Intra-continental trade does exacerbate the threat posed by the extra-continental introduction and, as such, should be given careful consideration.

The importance of the invasive species problem to the region has been recognized by the Commission on Environmental Cooperation (CEC), which has focused its efforts to date on aquatic ecosystems. Given the obvious links between trade and agriculture, as well as their importance to the region, this study will focus on the inter-relation among invasive species, agriculture and trade. The issue is notably complex and wide-ranging, and this paper does not purport to be a comprehensive scoping exercise. Instead, the intention is to provide an entrée into the topic and highlight future areas for investigation and policy development.

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[1] Note on Terminology: Non-native species, whether or not harmful, are known by a variety of different terms in the scientific and policy literature—exotic, introduced, foreign, alien, and non-indigenous species to name only the most common. For purposes of consistency, this paper follows the recent the work of the Convention on Biological Diversity in referring to such species. Thus: an "alien" species is any species found outside its natural or historic area of distribution; and, unless otherwise noted, an "invasive species" or "invasive alien species" refers to any such species that causes or may cause harm in its new environment.

Through the use of case studies and a more general analysis of the interrelation between trade and agriculture, the project seeks to:

- understand the impact that select invasive species and their pathways have on agricultural productivity throughout North America;
- outline institutional and legislative frameworks for existing regulatory systems and identify potential impediments therein to addressing alien invasive species; and
- identify and evaluate possible solutions, including approaches to addressing these impediments, which can be used to address broader issues relating to invasives species in the region.

The analysis begins with a brief overview of invasive alien species introductions, both intentional and unintentional, that pose the greatest threat to agricultural productivity within Canada, Mexico and the U.S. It will also address the relation between the introduction of invasive species and increases in trade volumes prior to and during NAFTA. Finally, the overview will outline the major institutional and legislative components for regulating invasive species within each of the NAFTA countries, as well as at the regional and international levels.

The report will then examine three cases studies in more depth: the Asian long-horned beetle; plum pox virus; and genetically modified maize. Given the close relationship of forestry to agriculture, the paper will also consider silviculture extraction and related activities (e.g., maple syrup production) under the larger rubric of agriculture. The case studies will review:

- the particular origin and biology of the species;
- the major pathway(s) for its introduction;
- agricultural impacts;
- relevant national and regional policies and procedures for responding to the invasive;
- levels of trade in the pathway; and
- potential recommendations particular to the species or pathway.

Overall, the cases will attempt to examine the structural adequacy of existing regulatory mechanisms for facing the challenges posed by increased trade. The study concludes with a broader set of recommendations to address issues of capacity and technology and to minimize risks posed by other potential or existing threats by invasive alien species.

1.1 Overview of Invasive Species' Impacts on Agriculture

Invasive alien species adversely impact agricultural production. The vast majority of these insect, weed and pathogen invaders have been introduced inadvertently, arriving via commerce in association with produce and grain shipments, living plants and soil, cut flowers, wood products and dry ballast (Pimentel 1993, OTA 1993, Cox 1999). In the agricultural context, the impacts from and costs of invasive species can be divided broadly into six categories: crop losses, rangeland value decline, water resource depletion, livestock disease, genetic contamination, and management and eradication costs.

1.1.1 Crop Loss

One of the most prominent impacts of invasive species is direct loss of crops due to infestations. While native insects and pathogens can, and do, inflict damages to crops, exotic species have been shown to account for 67% of crop losses in California (Dowell and Krass 1992) and 98% of crop pests in Hawaii (Beardsley 1991). As mentioned above, one recent calculation indicates that 40% of all insect damage to crops in the U.S. is attributable to alien species, causing US$13 billion in crop losses every year (Pimentel et al. 2000).

A complete enumeration of insects and pathogens responsible for crop loss in North America is beyond the scope of this document. However, a few examples deserve mention, as they have the potential to cause widespread losses to economically valuable crop species. The boll weevil (*Anthonomous grandis*), now largely eradicated from the southern U.S., is estimated to have caused US$100 million per year in losses to cotton since its introduction from Mexico in 1892 (Purdue University Boll Weevil Fact Sheet 1995). The alfalfa weevil (*Hypera postica*) accounts for about US$500 million in crop losses every year, and the Russian wheat aphid (*Diuraphis noxia*), which entered Mexico in 1980 and the U.S. in 1996, is responsible for about US$170 million in damages (Devine 1998).

Invasive species do not respect national borders and have affected cross-border ecosystems throughout North America. First documented in Massachusetts in 1827, the exotic plant leafy spurge (*Euphorbia esula*) now covers millions of square kilometers on both sides of the U.S.-Canada border, ranging from Prince Edward Island in the east to California and British Columbia in the west. In 2000, the U.S. banned imports of potatoes from Canada's Prince Edward Island given an outbreak of potato warts (caused by the fungus *Synchytrium endobioticum*), which had been subject to previous eradication efforts in the U.S. Lost sales were estimated at C$30 million, and overall costs stemming from the six-month ban were over C$83 million (Office of the Auditor General 2002: 7). The U.S. and Mexico have also taken joint efforts to combat the Mediterranean fruit fly (*Ceratitis capitata*), which attacks citrus trees, and the pink hibiscus mealy bug (*Maconellicoccus hirsutus*), which attacks over 120 plant species including fruit trees, vegetables and ornamental plants.

The entry of one alien species can also hasten the spread of another. The glassy-winged sharpshooter (*Homalodisca coagulata*) is a homopteran species that probably entered California in the late 1980s on imported plant material. This insect quickly became an important new vector for the bacterial Pierce's disease (*Xylella fastidiosa*), which now threatens grapevines, causing US$40 million in damages to California's wine, raisin and grape production (Siebert 2001). Exotic weedy plants also reduce crop yields, causing an estimated US$24 billion in annual losses (Pimentel et al. 2000). Another example is the cactus-borer *Cactoblastis cactorum*, a moth native to southeastern Latin America, which has been used in Australia and elsewhere to control species of introduced cacti. Now found throughout the Gulf Coast region, the moth presents a severe threat to more than 57 species of native cacti in the genus *Opuntia* found in Mexico on over

3,000,000 hectares. The genus *Opuntia* is one of the most used plants in Mexico and Central America, with many species considered valuable for animal forage, human food and a number of other applications (Soberon, et al. 2002; Gunter Zimmerman, et al 2002).

The timber industry is also threatened by a range of invasive species. Both Canada and the U.S. have been working to control the introduction and spread of the Asian long-horned beetle (*Anoplophora glabripennis*) and the brown spruce long-horned beetle (*Tetropium fuscum*). Should existing quarantine and control measures fail, the brown spruce long-horned beetle could present a significant threat to Canada's softwood lumber industry which averages over C$13 billion annually in sales. Similarly, the Asian long-horned beetle could threaten Canada's hardwood timber industry (C$480 million) and maple syrup and sugar products (C$130 million) (Office of the Auditor General of Canada 2002: 10).

1.1.2 Rangeland Value Decline

Invasive plants also impact the agricultural economy by decreasing the forage value of rangelands. Examples include yellow starthistle (*Centaurea solstitialis*), which is now present in 40% of California's grasslands, and a host of other exotic thistle species that are unpalatable to cattle and other livestock. Leafy spurge (*Euphorbia esula*) causes stomach irritation and lesions to cattle, which significantly decrease foraging when the species is found in the plant community. Leafy spurge infestation has dropped the value of some ranch lands by 90%, and is estimated to cause US$24 million in direct impacts to ranchers in North Dakota alone (Devine 1998). In Saskatchewan, efforts to control leafy spurge cost over C$7 million annually (Office of the Auditor General 2002: 10). Cheatgrass (*Bromus tectorum*) has intensified fire cycles in the U.S. intermountain West, causing tens of thousands of acres of forage land to burn annually (Devine 1998). Overall, alien weeds decrease the value of forage lands by about US$1 billion per year, or nearly 10% of their total value (Pimentel et al. 2000).

1.1.3 Water Resource Depletion

Water resources are crucial to agriculture, and in some places are under serious threat from exotic invasive species. A native to Eurasia, tamarisk, or saltcedar (*Tamarix* spp.) was introduced into the U.S. 100 years ago to control erosion and provide windbreaks. It now infests over 1.2 million acres of streamside habitat in Mexico and throughout the southwestern U.S. Its extremely deep root systems draw up and transpire huge quantities of water – an estimated 1.2 to 2.4 million acre-feet per year. The irrigation value of this water loss is estimated at US$39 million to US$121 million annually (Zavaletta 2000). Paperbark tree (*Melaleuca quinquenervia*), a serious invader in the Everglades, alters hydrological cycles, upon which both agriculture and wildlife communities depend, through its profuse transpiration and dense litter mats (Devine 1998).

1.1.4 Livestock Diseases

Several livestock diseases cause economic losses, and the U.S. Department of Agriculture (USDA) expends significant resources each year to keep even more damaging diseases out of the U.S. Brucellosis, which causes spontaneous abortions in cattle, results in US$1 million in losses annually. Pseudorabies, which kills young piglets, results in US$13.5 million in losses annually (APHIS Veterinary Services Data). In Mexico, of the four national emergency alerts announced by the National Commission for Farming Health, three were for animal health issues, including equine encephalitis, an avian virus affecting birds and poultry and a pathogen specifically affecting cattle (PROFEPA). Exotic Newcastle Disease, a highly contagious viral illness that is nearly 100% fatal to many bird species, has the potential to cause millions in losses to the poultry industry.

The recent outbreak of foot and mouth disease in the U.K. led the USDA to double its inspection and quarantine efforts to prevent the “grave economic as well as physical consequences” from manifesting in the U.S. (APHIS Program Aid No. 600). West Nile virus threatens horses and poultry, as well as humans in the U.S. and increasingly in Canada. Finally, the transmissible spongiform encephalopathy disease group could have potentially devastating economic consequences. Such diseases include scrapie, which occurs in the U.S., and mad cow disease, which to date does not. The NAFTA countries have worked to develop a coordinated rapid response system to share information and control any sitings of the disease.

1.1.5 Genetic Contamination

In the era of emerging biotechnologies, genetically modified (GM) plants, animals and other propagative materials have the potential to become invasive, thereby presenting a range of unique threats and regulatory needs. Significant attention needs to be paid to examining how genetically modified organisms (GMOs) as novel genetic constructs will interact with the natural environment and potentially impact similar and dependent species.

To date, there are a number of cases where GM crops have been found in new and unexpected locations. One of the case studies below details the spread of transgenes from GM maize within Mexico, the center of origin and diversity for maize. Documented examples exist of pollen from GM varieties “contaminating” crops on organic farms, thereby compromising their organic status and commercial value. Similarly, there is the case of Percy Schmeiser, a farmer in Saskatchewan, whose crops, according to testimony, were pollinated by a variety of Monsanto’s patented “Round-up Ready Canola.” The resulting legal case found Schmeiser guilty of patent infringement and ordered to pay Monsanto $172,000 in damages, despite the fact that the variety likely was transmitted by natural means. (The case is now under appeal.) Similarly, concerns are arising about the use of GM salmon and other fish in aquaculture given the prevalence for escapes into the wild.

1.1.6 Management and Eradication Costs

The USDA Animal and Plant Health Inspection Service (APHIS) spent nearly US$160 million dollars on management of exotic pests and diseases in 2002, and anticipates spending nearly US$250 million in 2003 (USDA Budget Summary, FY 2004). For example, U.S. taxpayer expenditures for boll weevil eradication totaled US$77 million in 2002 and are estimated to cost US$34 million in 2003 (USDA Budget

Summary, FY 2004), and eradication of Mediterranean and Mexican fruit fly outbreaks cost US$37 million in 2002 and is estimated to cost US$63 million in 2003 (USDA Budget Summary, FY 2004). If these species were to become established, the costs in crop damage and lost export markets could exceed US$821 million per year (USDA APHIS Fruit Fly Program Information). The cost of pesticides and fungicides to treat introduced insects and pathogens probably exceeds US$1 billion per year, and farmers and ranchers spend about $8 billion to control invasive exotic weeds in croplands and pastures (Pimentel et al. 2000). In Canada, costs to address an outbreak of potato warts on Prince Edward Island in 2000-01 were C$12.6 million, but totaled over C$83.5 million when additional compensation, disposal and monitoring costs were incorporated. (Office of the Auditor General 2002: 7). Total expenditures for management and eradication costs are generally difficult to compile given that costs and efforts are spread across different federal and state/provincial level authorities and programs.

1.2 Overview of Trade Flows and Invasive Species' Introductions

Known and potential invasive species (even those relevant primarily to agriculture) follow a vast and divergent array pathways into and within North America. Potential invaders arrive intentionally, as pets, food stocks, or ornamentals, and unintentionally, as contaminants in agricultural produce, nursery plans, cut flowers, timber, seeds and soils, livestock, machinery, hiking boots, ships ballasts, and packing materials of many kinds. (GISP 2003) For this reason, it is not possible within the context of the present paper to provide a comprehensive overview of the volume and structure of inter-continental and intra-continental relevant to the control of invasive species. Nor is it feasible with available data to make a precise assessment of the impact of agricultural trade flows on species invasions, relative to other pathways. While it is self-evident that agricultural trade is both a major pathway for and a major victim of harmful invasions, significant gaps and inconsistencies in the reporting of national trade data and national invasive species interdictions raise currently insurmountable barriers to quantitative analyses of the relationships.

Nonetheless, our research indicates several salient factors to be taken into consideration in future studies and policy decisions.

1.2.1 The geographic and physical context

In assessing the vulnerability of North America to species invasions, and the relationship of trade to that vulnerability, it is important to understand the geographic and physical context in which that trade occurs. Together, Canada, Mexico and the United States cover an area of 21,773 km^2 (9,400 mi^2). This area encompasses tremendous physical and climatological diversity, and a startling array of ecotypes--tundra and taiga, savannah and tall grass prairie, desert and wetland, temperate hardwood, tropical wet and tropical dry forest, cloud forest and mangrove swamp, freshwater estuary and coral reef. The territory of the three NAFTA countries lies within three of the world's seven biogeographic realms (Nearctic, Neotropical and Oceania). The three countries include at least 38 broad ecoregions representing all but one of the 26 "major habitat types"—terrestrial, freshwater and marine—recognized by the World Wildlife Fund (WWF 2002). To a level unique in the world, Canada, Mexico and the United States provide viable habitat—somewhere within their borders—for every conceivable alien invader.

The physical infrastructure by which alien species can be transferred from one habitat (and one ecosystem) to another is equally remarkable. These ecosystems are connected to each other, and to the larger world, by:

- 7.5 million kilometers of roads (including 6.3 million km in the United States);
- 46,000 kilometers of navigable inland waterways;
- 390,000 kilometers of rail lines, 15,432 airports (including 18 of the 30 busiest airports in the world);
- 580 water ports and facilities; and
- more than 12,000 kilometers of land boundaries crossed by
    - 132 legal ports of entry along the U.S.-Canada border; and
    - 25 legal ports of entry between the U.S. and Mexico.

(U.S. DOT-BTS 2002; CIA 2002; Airports Council International 2003). [2]

By most measures, the level of connectivity in North America far exceeds that found in any equivalent land area. As Table 1 demonstrates, the three NAFTA countries account for more than half the world's airports. Only Asia, with 49 countries and more than twice the total area, has comparable amounts of road and rail infrastructure. Although North America reports fewer "major marine ports" than other regions, the United States includes five of the world's 25 busiest ports. (U.S. DOT-MARAD. 2002) The United States alone accounted for 10% of world port calls in 2000, with 48% of the active world fleet—nearly half of all vessels—calling at U.S. ports. (U.S. DOT-MARAD. 2001)

Table 1. Global Transportation Infrastructure by Region

		Transportation Mode				
Region/ (# countries)	**Area (km^2)**	*Highways (km)*	*Rail (km)*	*Inland Waterways (km)*	*Major Marine Ports*	*Airports*
Asia (49)[3]	48,670,642	7,301,968	410,410	160,259	179	4,735
Africa (46)	30,092,557	1,691,297	81,867	55,264	210	4,571
N. Am. (3)[4]	21,321,300	7,334,867	342,648	46,909[5]	52 (70)[6]	18,473
S.Am. (13)	17,818,505	2,399,260	87,586	104,793	98	1,797

[2] These figures do not include transportation figures for Hawaii, Puerto Rico, Guam, or the U.S. Virgin Islands.
[3] Including Russia, Indonesia, Malaysia and the Philippines.
[4] Excluding Bermuda, Greenland, St. Pierre and Miquelon, and U.S. overseas territories of Puerto Rico, USVI, American Samoa, Northern Mariana Islands and Guam.
[5] Inland waterways figure for North America excludes the Great Lakes and St. Lawrence Seaway.
[6] Figure in parentheses includes Puerto Rico, USVI, American Samoa, Northern Mariana Islands and Guam

Oceania (24)[7]	8,509,148	967,624	45,842	21,125	78	1,335
Europe (45)	5,952,610	5,996,840	285, 852	22,520	134	2,427
C. Am. (29)[8]	758,883	204,122	18,889	6,452	118	1,752

(Adapted from: USDOT-BTS. 1997)

As a result of this connectivity, the considerable likelihood that flora, fauna or pathogens established in one NAFTA party may be communicated to another should not be ignored. As discussed in greater detail in section 2 below, the current system for preventing the unintentional communication of alien species across NAFTA borders is woefully inadequate. As one report has observed:

> Even from a phytosanitary viewpoint, the U.S. and Canada enjoy an open trading relationship. For example, Canada is the only country exempt from the U.S. general prohibition on plant imports established in growing media under Quarantine 37. This openness reflects a long-standing assumption that trade between the two countries represents a low risk of harmful invasive species introduction. Unfortunately, recent experience has made that assumption obsolete. Exotic fruit fly host material has found its way into the U.S. in both commercial-volume shipments and via the traveling public. Such materials are prohibited entry into the U.S., but freely enter Canada. Canada is unconcerned because fruit flies will not permanently establish due to climate. Canada's entry requirements for a variety of other offshore-produced commodities, such as nursery stock and propagative material, are also inconsistent with those of the U.S.

(Source:). Even with dramatic improvements in control systems, however, efforts to control unintentional transboundary movements of invasives within North America will face Herculean odds.

1.2.2 Trade flows into and within North America

1.2.2.1 Trade flows within North America—Volume and Structure

Canada is the largest and Mexico the second largest trading partner of the United States. (ITA (Trade and Economy Data and Analysis) Canada is Mexico's fourth largest trading partner and Mexico is Canada's fifth largest trading partner. (Source: Canada Trade Mission to Mexico) The United States is the largest trading partner for each of the other NAFTA countries. Not surprisingly, then, over 200 million border crossings took place between the US and Canada in 1999. And over 300 million border crossings took place between the US and Mexico. (US DOT-BTS 2003). Even with significant increases in inspection personnel at every border crossing, the proportion of vehicles and shipments inspected will remain only a tiny portion of the whole.

[7] Including American Samoa, Northern Mariana Islands, and Guam.
[8] Including Puerto Rico and USVI.

Control efforts are further complicated by the structure of regional trade flows. Tables 2a-c show regional trade flows by mode in 1996, the most recent year for which complete data is available.

Tables 2a.-2c. Intra-Continental Trade by Mode of Transportation, 1996

Table 2a. Canada—Trade with NAFTA, 1996							
Transport. Mode	*Canada—Imports (millions $US)*				*Canada—Exports (millions $US)*		
	fr Mexico	fr USA	fr NAFTA		to Mexico	to USA	to NAFTA
Total	4,426	115,118	119,614		922	163,682	164,604
Road	2,791	91,997	94,778		301	96,534	96,835
Rail	1,207	10,134	11,341		122	37,050	37,172
Air	253	10,597	10,850		122	7,315	7,437
Water	54	1,771	1,825		377	5,134	5,511

Table 2b. Mexico—Trade with NAFTA, 1996							
Transport. Mode	*Mexico—Imports (millions $US)*				*Mexico—Exports (millions $US)*		
	fr Canada	fr USA	fr NAFTA		to Canada	to USA	to NAFTA
Total	1,744	67,437	69,181		2,170	80,541	82,711
Road	895	48,181	49,076		606	53,752	54,358
Rail	195	48,589	48,784		1,272	12,681	13,953
Air	134	2,341	2,475		103	2,097	2,200
Water	370	3,314	3,684		181	11,306	11,487

Table 2c. United States—Trade with NAFTA, 1996							
Transport. Mode	*United States—Imports (millions $US)*				*United States—Exports (millions $US)*		
	fr Canada	fr Mexico	fr NAFTA		to Canada	to Mexico	to NAFTA
Total	156,506	72,963	229,469		133,688	56,761	190,449
Road	98,401	48,350	146,751		102,743	44,092	146,835
Rail	39,811	12,298	52,109		15,679	5,119	20,798
Air	6,325	1,870	8,195		12,541	2,362	14,903
Water	4,968	8,797	13,765		2,066	3,143	5,209

(Source for Tables 2a-2c: USDOT-BTS 1997.)

Not surprisingly, given the transportation infrastructure of the three countries, the bulk of trade between the three countries is carried by road. The NAFTA parties have combined commercial freight vehicle fleets of nearly 11 million vehicles. (US DOT-BTS. 1997) Based on the figures in Tables 2a-c, commercial freight shipments accounted for 69% of the value of NAFTA imports into the three NAFTA countries. Rail freight accounted for an additional 27%. These shipments must be funneled through 132 border crossings on the U.S.-Canada border and 25 on the U.S.-Mexico border. Moreover, a disproportionate percentage of the commercial traffic is concentrated at only a few key crossings (e.g., Detroit, Buffalo-Niagara, and Blaine, Washington in the North, and) In 1997, nearly 1.5 million trucks and 4,606 freight trains entered the United States through the checkpoint at Detroit, Michigan—an average of 162 trucks per hour and 13 trains per day.[9] Comparable numbers entered Laredo, Texas from Mexico. Inspectors in Canada and Mexico face similar odds.

[9] http://www.bts.gov/itt/cross/.

1.2.2.2 Containerization

Across all modes of transportation, there is a growing trend toward the containerization of cargo, which makes border inspection (or internal inspection) even more challenging. Between 1990 and 2001, container traffic in U.S. and Canadian ports nearly doubled, from 17.7 million twenty-foot equivalent units (TEUs) in 1990, to 33.3 million TEUs in 2001. Since 1982, the volume of containerized trade has increased steadily at an approximate rate of 8%/year. (AAPA 2003a) In Mexico, container traffic more than tripled in the 1990s—from 324 thousand TEUs in 1990 to 1.3 million TEUs in 2000. (AAPA 2003b). As with trucks and trains, containerized cargo shipments are overwhelmingly concentrated at a small number of ports. Ten U.S. ports handled 83.4% of the country's container traffic in 2001. The port of Los Angeles handled 3.4 million TEUs—an average of 9,384 TEUs per day.[10]

Cargo containers are particularly effective transports for hitchhiking wildlife. As the Global Invasive Species Programme has observed:

> The use of shipping containers offers considerable scope for stowaways, and they are difficult to inspect adequately. In one extreme case, a raccoon survived for about five weeks in a container while it was shipped from the USA to Europe and was still able to walk out of the container. Containers used to transport raw timber frequently carry many associated species. Even apparently "clean" cargoes can carry invaders such as the scorpions recently transported from Portugal to New Zealand in new empty wine bottles despite reported fumigation of the container before departure. (GISP 2003)

The physical characteristics of shipping containers render careful inspection extremely difficult. The growing volume in which they are entering North American ports further increases the challenge facing inspectors. More seriously, because of their self-contained nature, cargo containers can be readily transferred from one mode of transportation to another, further facilitating the undetected movement of alien species from shipboard to road or rail and their subsequent distribution throughout the continent. Cargo containers are already transferred directly to trucks and trains at a number of ports, and new rail freight corridor projects are underway to locate railheads at points of entry are underway in many locations. (USDA-APHIS 1999.)

1.2.2.3 United States as the most likely entry point for invasive species

One unexpected conclusion of our study is that, by virtue of its far greater role in inter-continental trade, the United States is much more likely than either of its NAFTA partners to serve as the initial North American entry-point for a potential invasive.

The vast majority of goods and people arriving in North America arrive by way of the United States. In 2001, the three NAFTA parties imported US$1.58 trillion in

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[10] <http://www.bts.gov/transtu/indicators/Special/html/Waterborne_Foreign_Trade_Containerized_Cargo.html>

merchandise, representing nearly 25% of total world imports. Of those imports, US$624 billion originated within NAFTA itself; the remaining US$954 billion originated outside the region. U.S. imports alone accounted for US $1.18 trillion, with roughly 70% of those imports originating outside North America. Canada, the second largest North American importer, imported US$ 227 billion in goods; however, imports from the United States accounted for 73% of that total. Mexico imported $176.2 billion in goods, again primarily from the United States. (WTO 2002)

As noted in the preceding section, one in every two marine vessels in the world's active fleet visited the United States in the year 2000, accounting for 10% of world port calls. Cargo ships representing more than 2.7 billion dead weight tons of capacity arrived in U.S. ports that year, with most of this capacity (77%) accounted for by only 20 ports. (US DOT-MARAD 2000) Similarly, the United States had fourteen of the world's thirty busiest airports by cargo volume, accounting for 17.6 million metric tons of cargo. (ACI Traffic Data 2002)

While alien species can and do enter North America through any of the three NAFTA parties, the United States' disproportionate role in the flow of goods into the continent makes it the most likely entry point for invaders originating outside NAFTA. The significance of this fact for future invasives policy within and among the three NAFTA parties warrants consideration.

1.3 Overview of National, Regional and International Institutions and Agreements

The following sections detail the institutional and legislative systems that the three NAFTA countries use to prevent and regulate the introduction of invasive species within the agricultural context. The final section details the international and regional instruments and agreements that set the broader framework for developing such rules, as well as for improving cooperation among the three countries for developing mutual approaches to combating invasives that present a common threat.

1.3.1 Canada

Canada has a range of institutions and legislation in place and under development to address the introduction of invasive species into its territory, concentrated in areas of : agriculture and forestry; inland waters and marine ecosystems; and terrestrial ecosystems and habitat. The institutions addressing agricultural and forestry resources are most developed, and estimates place the annual damage to these sectors at C$7.5 billion. On average Canadian inspection agencies can only inspect 1-2% of all incoming shipments for potential invasives. This is exacerbated by rapid increases in the bulk of imported goods, which increased 40% over the 1990s (Office of the Auditor General, 2002: 5).

A recent assessment by the Commissioner of the Environment and Development was very critical of Canada's ability to protect its other ecosystems from invasives, stating that:

> Environment Canada has not co-ordinated the federal efforts to identify present and potential invaders that threaten Canadian ecosystems and their key pathways of arrival into Canada. It has not organized a comprehensive assessment of the risks that invasive species pose to our environment and economy (Office of the Auditor General 2002, 13).

In response to this, Environment Canada and associated agencies are working to develop a comprehensive approach to the invasives issue, as outlined in the National Biodiversity Strategy.

With regard to crop loss, Canada has identified species of highest priority for preventing introduction or eradicating:

- Insects: gypsy moth, leek moth, leopard moth, oriental fruit moth, white-spotted tussock moth, apple ermine moth, Asian long-horned beetle, brown spruce long-horned beetle, cereal leaf beetle, Japanese beetle, pine shoot beetle, blueberry maggot and apple maggot;
- Fungi: European larch canker, scleroderris canker, eastern filbert blight, oak wilt, Dutch elm disease, chrysanthemum white rust and potato wart;
- Nematodes: soybean cyst nematode; and
- Viruses: little cherry virus and plum pox virus.[11]

Additionally, the table below details the report interceptions of invasive pests caught entering Canada during border inspections.

Table 3. Reported Interception of Invasive Pests[12]

Pest Type	**Number of Interceptions**		
	1997-98	1998-99	1999-2000
Arthropods & Mollusks	402	546	860
Nematodes	514	100	187
Fungi & Bacteria	67	33	27
Total	**983**	**679**	**1074**

Of these interceptions, the largest quantities were introduced from the U.S. and China, while minimal introductions came from Mexico. Additionally, the largest quantity of introductions according to pathway came from wood products (raw lumber, packing, crates, pallets, etc.).

1.3.1.1 Agencies

Several federal agencies in Canada share responsibility for controlling invasive species risks:

- **Canadian Food Inspection Agency (CFIA) –** Within the department of Canadian Agriculture and Agri-Food, the CFIA provides all federal inspection

[11] This data is for the 1999-2001 period. See plant pest surveillance reports at <http://www.inspection.gc.ca/english/ppc/science/pps/situe.shtml>

[12] Information, including particular species, host/carrier and origin, are available at <http://www.inspection.gc.ca/english/lab/cpqp/introe.shtml>.

and enforcement services related to food, including domestic and international regulations and standards for safety, quality, quantity, composition, handling, identity, processing, packaging and labeling. The agency develops procedures to reduce risk of entry of pests and invasives into Canada, and performs surveillance to identify, control or eradicate regulated pests that have gained entry to Canada. The CFIA addresses both plant and animal health, and has risk assessment processes for more than 350 types of cargo, diseases and pests. The CFIA is the designated authority for implementation of the Seeds Act, Feeds Act, Fertilizers Act, Health of Animals Act and Plants Protections Act.

- **Pest Management Regulatory Agency (PMRA) –** Under Health Canada, PMRA is responsible for providing access to pest management tools. Additionally, PRMA seeks to minimize risks to environmental and human health, including assessment of products used to control alien species.

- **Canadian Forest Service (CFS) –** Under Natural Resources Canada, the CFS is the principal federal forest research organization in Canada, which addresses invasive forest pests by providing information on: ecological aspects of potential alien forest pests and methods for detection, identification and monitoring; assessments for the potential establishment and spread of alien forest pests; systems for predicting such invasions; and mitigative and preventative measures, including silvicultural options, and decision support systems.

- **Environment Canada (EC) –** EC is the lead agency on the overall topic of invasive species affecting non-agricultural ecosystems. It has outlined the general objectives of Canada's approach to invasives within the National Biodiversity Strategy, and is currently involved in developing a national strategy on the prevention and control of invasive species. EC includes the Canadian Wildlife Service (CWS) and the Biodiversity Convention Office (BCO). The CWS addresses invasives issues affecting Canadian wildlife, and the BCO is responsible for liaising internationally on invasives and other issues related to the Convention on Biological Diversity (CBD).

- **Fisheries and Oceans Canada (FOC) –** Fisheries and Oceans Canada is responsible for conserving and protecting fish, including their habitat and food, while also addressing issues regarding shipping and navigation. With regard to invasives, the FOC performs scientific research and provides scientific advice in connection with ballast water regulations and standards.

- **Transport Canada –** Transport Canada is the agency responsible for developing and administering policies, regulations and services regarding transport by rail, road, plane and waterway. With regard to invasive species, it is responsible for regulating and controlling the management of ballast water on ships and preventing or reducing the release of foreign aquatic organisms or pathogens by ships entering Canadian waters.

1.3.1.2 Legislation

- **Plant Protection Act (1990) –** The act is designed to prevent the importation, exportation and spread of pests injurious to plants and to provide for their control and eradication, and for the certification of plants and other things. The act addresses the roles of inspection, import and exportat of goods which may contain invasive species. The Act also provides details regarding the handling of infested places, limits on liability, fees and compensation, and criminal punishment. Regulations for implementation of the Act were approved in 1995 and provide greater detail with regard to inspections, permitting and certificates, quarantine procedures, places/ports of entry, packaging and labeling, and prohibitions. The regulations also include two schedules: schedule one lists plants or pests whose movement is prohibited within Canada; and schedule two lists plants or pests whose movement is restricted.

- **Seeds Act (1985) –** The act relates to the import and export of seed with specific regard to issues of labeling, packaging, purity and inspection. The implementing regulations more specifically address standards and guidelines for seed varieties (e.g., cereals, grasses, forages), including purity, grade, labeling and sale. A special classification is devoted to potato seeds with regard to their certification (e.g., nuclear stock, pre-elite, elite) and determination as free of potential pests and pathogens. There are also eight provincial weed acts, which operate in tandem with the federal Seeds Act to specifically address noxious weeds that may impact agricultural productivity.

- **Health of Animals Act (1990) –** The act addresses the import, export and movement of animals and their by-products including the control of diseases and toxic substances, prohibitions, rules for infected places and control areas, inspection, search and seizure, compensation, fees and limits on liability. The Health of Animals Regulations provide more specific details on implementation, including segregation and confinement of animals, importation of germplasm and animals, rules on specific products (e.g., dairy and eggs, animal by-products, fodder), eradication of diseases, means of transportation, veterinary biologics, permitting and licensing.

- **National Biodiversity Strategy (1995) –** The strategy as drafted per the requirements of the CBD, includes a number of elements related to the prevention, eradication and control of invasives. Key priorities include to:
    - develop and implement effective means to identify and monitor alien organisms;
    - develop national and international databases that support the identification and anticipation of the introduction of potentially harmful alien organisms to develop prevention and control measures;
    - determine priorities for allocating resources;
    - identify and eliminate common sources of unintentional introductions;

- ensure that there is adequate legislation and enforcement to control introductions or escapes of harmful alien organisms; and
- improve preventive mechanisms such as screening standards and risk assessment procedures.

1.3.2 Mexico

The most biologically diverse of the three countries, Mexico has a particular interest in ensuring that the introduction of invasive species does not threaten natural biodiversity or agricultural interests. Similar to Canada, national efforts initially focused on the agricultural sector, particularly crops and livestock. However, more recent efforts over the past decade have also contributed to developing a national strategy and the necessary institutional capacity to address invasions of natural ecosystems.

1.3.2.1 Agencies

Within Mexico, responsibility for controlling invasive species risks is shared among four federal agencies:

- **Secretary of Agriculture, Ranching, Rural Development, Fisheries and Nutrition (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación* – Sagarpa)** Sagarpa oversees the sectors of agriculture, fishing and ranching with the goal of improving productivity and integrating rural economic development in the farming sector. Sagarpa focuses on issues related to invasives and agriculture, particularly examining the listing of invasive species and pathways, as well as application of phytosanitary and zoosanitary measures for control and eradication. Sagarpa is also responsible for collaboration with Canadian and U.S. authorities.

- **National Commission for Farming Health (*Comision Nacional de Sanidad Agropecuaria* – Conasag) –** Within Sagarpa, Conasag is a national commission charged with inspecting for and regulating invasive species. In cases of invasives species that present an immediate threat to animal or plant species, Conasag can issue a national emergency alert (*Dispositivo Nacional de Emergencia*). The National Advisory Phytosanitary Council (*Consejo Nacional Consultivo Fitosanitario* – Conacofi) is responsible for taking action on threats to plant health, and the Main Directorate for Animal Health (*Direccion General de Salud Animal* – SAGAR) for animal and livestock health.

- **Secretary of the Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales* – Semarnat) –** Semarnat is generally in charge of wildlife and environmental issues. Within Semarnat, the Federal Attorney General for Environmental Protection (*Procuradia Federal de Proteccion al Ambiente* – Profepa) monitors the protection of Mexico's wildlife, forests and protected areas, reviews environmental impact authorizations and responds to citizen complaints regarding environmental damage. Profepa is the responsible agency for addressing and controlling invasive species that threaten Mexican wildlife. In cases where an invasive might threaten wildlife as well as agricultural plants or animals, Profepa coordinates with Sagarpa. Additionally, within Semarnat, the Main Directorate for Forestry (Dirección General Forestal) is responsible for regulating the phytosanitary requirements regarding lumber and other forest products to prevent the introduction, establishment and spread of invasive species.

- **National Commission for the Knowledge and Use of Biodiversity (*Comision Nacional para la Conocimiento y Uso de la Biodiversidad* – Conabio) –** Conabio is an inter-ministerial Commission established to gather information and develop projects regarding national biodiversity resources. Conabio is implementing projects to catalog invasive species and to study potential invasion pathways through computer modeling and development of databases. In this regard, Conabio collaborates with NGOs, research institutions and universities on these research efforts. Conabio is in the process of developing a list of invasive species, which includes 50 mammals, 50 birds and 5 reptiles/amphibians, and is considering the inclusion of more than 200 species of plants.

1.3.2.2 Legislation

- **Federal Law on Plant Health (*Ley Federal de Sanidad Vegetal*, 1994) –** The law governs the use of phytosanitary standards and regulations to protect plant health with particular attention to preventing the introduction and spread of pests or diseases that may impact vegetables, their products and by-products. The law governs imports and exports of plants and plant products, as well as other materials and machinery that may serve as a potential pathway for introductions, by requiring phytosanitary certificates for: vegetables, their products or by products, agents and any related materials and equipment; vehicles used for transporting and materials used in shipping, packing and containment; agricultural and forestry machinery. The law also addresses the development of phytosanitary standards and the role of inspection and customs agents to ensure the provision of appropriate certificates for imported merchandise. It establishes a national emergency system to alert appropriate authorities about the detection of species that present a phytosanitary threat and to coordinate the application of necessary measures to prevent or control the spread of an invasive. The law also defines financial penalties for violations on importing or exporting goods without the appropriate phytosanitary certificate.[13]

- **Federal Law on Animal Health (*Ley Federal de Sanidad Animal*, 1993) –** Similar to the law on plant health, this law governs the zoosanitary standards and procedures necessary to protect animal and livestock health. It establishes a national zoosanitary regulatory structure to be implemented by SAGARPA in collaboration with the Secretary of Housing and Public Credit (*Secretaría de*

[13] This law also relates to the Reglamento de la Ley de Sanidad Fitopecuaria de los E.U.M. en materia de Sanidad Vegetal (1980), which provides more specific details on relevant movement, inspection and quarantine measures.

Hacienda y Crédito Público) for the inspection and enforcement of regulations of imports at ports of entry. The movement, import or export of animals, their products and by-products (including those for use in animals or for their consumption) requires an accompanying zoosanitary certificate. The law also details the development of further standards for regions or countries where particular diseases or pathogens have been identified. The law also establishes a national emergency notification system requiring the development and implementation of safety measures to prevent introductions. The law also details infractions and penalties for violations including fines, revocation of licenses and closure of facilities.

- **General Law of Ecological Equilibrium and Environmental Protection (*Ley General del Equilibrio Ecologico y la Proteccion al Ambiente*, 1986, latest revision 2000) –** This law generally addresses the preservation and protection of the natural environment, including the country's biodiversity and natural resources. Regarding invasives it specifically requires authorization for: use of alien, hybrid or transgenic species in reforestation and breeding activities; activities that may endanger species preservation or damage natural ecosystems; and introduction of alien, hybrid and transgenic species in aquatic ecosystems.

- **General Law on Wildlife (*Ley General de Vida Silvestre*, 2000) –** The law generally addresses wildlife conservation and protection issues. It specifically requires that any use of alien species must be done in confinement in accordance with a management plan approved by Semarnat. Such confinement conditions will vary by species with the goal to prevent negative impacts on species and ecosystems.

1.3.3 U.S.

Until recently federal response concerning invasive species was largely uncoordinated, consisting of a patchwork of laws, regulations, policies, and programs.[14] However, with the issuance of Executive Order 13112 in 1999, which created the National Invasive Species Council, and the consolidation of federal invasive species laws under the 2000 Plant Protection Act, the U.S. is moving toward a more coherent response to invasive species issues. As with Canada, however, the US currently has the capacity to inspect only 1% to 2% of all incoming shipments.

1.3.3.1 Agencies

- **National Invasive Species Council –** In February 1999, invasive species prevention and management efforts received heightened attention with the issuance of Executive Order 13112 on Invasive Species. The Order established the National Invasive Species Council (NISC), which consists of 10 Federal agencies.[15] The Order directs the Council to, "provide national leadership on

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[14] CRS Report for Congress IV 1999 Federal Agency Actions: A Patchwork

[15] The National Invasive Species Council is co-chaired by the Secretaries of Agriculture, Commerce, and the Interior; and includes the Secretaries of State, Treasury, Defense, Transportation, and Health and

invasive species; see that their Federal efforts are coordinated and effective; promote action at local, State, tribal and ecosystem levels; identify recommendations for international cooperation; facilitate a coordinated network to document and monitor invasive species; develop a net-based information network; and provide guidance on invasive species for Federal agencies to use in implementing the National Environmental Policy Act". The Order also directs the Council to form a non-federal Invasive Species Advisory Committee (ISAC) to advise the Council in its work.[16] The Council issued the National Invasive Species Management Plan in January 2001 fulfilling its mandate to minimize the ecological, economic and health impacts caused by invasive species by promoting cooperation between various government agencies.[17]

- **USDA Animal Plant Health Inspection Service (APHIS) –** At the federal level, APHIS is the primary department responsible for the implementation of NISC's management plan. USDA APHIS is responsible to conduct port of entry inspections and quarantine goods coming into the country, manage more than 190 million acres of national forests and grasslands, conduct research, and provide technical assistance to the private sector in extensive pest control projects. Under the 2000 Plant Protection Act, which consolidated the Plant Quarantine Act, the Federal Plant Pest Act and the Federal Noxious Weed Act, among others, USDA APHIS is authorized to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism or plant pest. APHIS Plant Protection and Quarantine (PPQ) is primarily responsible for the implementation of laws regarding invasive species. In addition to its responsibility to protect US agriculture, APHIS, in cooperation with the USDA Forest Service, U.S. Department of the Interior Bureau of Land Management, National Park Service, and Fish and Wildlife Service, protects forests, rangelands, and wetland ecosystems. APHIS utilizes a permitting system based on methods of risk assessment to assess organisms for plant pest risk or risk to animals.[18] APHIS is also responsible for implementing several multilateral and bilateral international treaties directly or indirectly related to invasive species. These include the International Plant Protection Convention, Convention on Prevention of Diseases in Livestock (United States-Mexico), Convention on International Trade in Endangered Species of Wild Flora and Fauna, Convention for the Protection of Migratory Birds (United States-Canada), and Convention for the Protection of Migratory Birds and Game Animals (United States-Mexico).[19]

- **Department of Homeland Security (DOHS) –** As part of the President's proposal to create a permanent Department of Homeland Security (DOHS), USDA APHIS inspectors are being transferred to the new DOHS to perform

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Human Services, as well as the Administrators of the Environmental Protection Agency and the US Agency for International Development.

[16] National Invasive Species Council <http://www.invasivespecies.gov/>

[17] National Invasive Species Management Plan <http://www.invasivespecies.gov/council/nmp.shtml>

[18] APHIS Factsheet Invasive Species <http://www.aphis.usda.gov/oa/pubs/invasive.pdf>

[19] APHIS <http://www.aphis.usda.gov/>

"border, transportation security, chemical, biological, radiological, and nuclear countermeasures" beginning March 1, 2003. While this move will mean a US$146 million increase in agriculture-related homeland security efforts, concerns are that it will divert inspectors' attention away from invasive species and focus their efforts on detecting possible biological, chemical, and nuclear weapons of mass destruction. In addition, invasive species policy-makers and researchers will remain as a part of USDA APHIS.[20]

- **Other Agencies –** The Fish and Wildlife Service (FWS), within the Department of Interior, regulates imports of wildlife (mammals, birds, fish, amphibians, reptiles, mollusks and crustaceans) under the Lacey Act, the Endangered Species Act and CITES. The Fish and Wildlife Service, National Oceanic and Atmospheric Administration (NOAA), U.S. Coast Guard, Army Corps of Engineers, EPA, and the Department of State (DOS) are responsible for implementing the Nonindigenous Aquatic Nuisance Prevention and Control Act to prevent and control aquatic nuisance species. The Department of Defense (DOD) is also involved with invasive species management when it assists APHIS with inspection of military shipments into and out of the United States. The DOD also monitors for invasive pests on all military bases. Finally, the U.S. Customs Service detains products that are awaiting APHIS or FWS inspection.[21]

1.3.3.2 Legislation

- **Plant Protection Act (1990) –** With the enactment of the Plant Protection Act (PPA) in June of 2000, 10 of USDA's existing plant health laws were consolidated into one comprehensive law. Under the PPA, the USDA US Department of Agriculture Animal Plant Health Inspection Service (APHIS) is authorized to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism or plant pest. The PPA also expanded the definition of a noxious weed to be included as a plant pest. Under the PPA, the Secretary of Agriculture and APHIS have the authority for the first time to declare an extraordinary emergency when a newly introduced or not widely prevalent noxious weed poses a significant threat. An extraordinary emergency declaration gives APHIS the authority to hold, seize, quarantine, treat, or destroy any plant or plant product being moved within a state that is believed to be infested with a plant pest or noxious weed. The PPA also incorporates, for the first time, specific mention of biological control in an APHIS statute. Biological control organisms, which were formerly grouped with plant pests, may now be distinguished by permits as potentially beneficial. The Quality Assurance provision of the PPA provides APHIS with the authority to cooperate with industry, states, and others to establish programs to certify the health and quality of a specific commodity. The PPA now also allows APHIS to publish industry-developed standards under its regulatory authority. Along with consolidating

[20] House Committee on Agriculture <http://agriculture.house.gov/5005sec.htm>
[21] APHIS Factsheet Invasive Species <http://www.aphis.usda.gov/oa/pubs/invasive.pdf>

APHIS' authorities, the PPA establishes more stringent deterrents and civil penalties against those charged with violating the Act.[22]

- **National Invasive Species Act (1996) –** The National Invasive Species Act (NISA) amended the Nonindigenous Aquatic Nuisance Prevention and Control Act to address the potential introduction of aquatic nuisance species through ballast water in US waters. To achieve this goal, NISA requires the Secretary of Transportation to issue voluntary guidelines to prevent the introduction and spread of nonindigenous species in U.S. waters by vessels equipped with ballast water tanks. The guidelines require all vessels entering U.S. waters after operating outside of the U.S. Exclusive Economic Zone (EEZ) to undertake high seas ballast water exchange or alternative measures that are environmentally sound and at least as effective as ballast water exchange in preventing and controlling infestations of aquatic nuisance species. These guidelines also require reporting and record keeping to allow the Coast Guard to determine the rate of compliance. The information collected by the Coast Guard is maintained by the Smithsonian environmental Research Center in a National Ballast Water Information clearinghouse. Under NISA, the Coast Guard must turn the voluntary guidelines into enforceable regulations if the Coast Guard determines that the rate of compliance with the voluntary guidelines is not adequate, or if the reporting and record keeping is not sufficient for the Coast Guard to determine the rate of compliance.[23]

- **National Aquatic Invasive Species Act of 2003 –** This Act, currently under consideration by Congress, would reauthorize and amend the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended by the National Invasive Species Act of 1996. This Act establishes a mandatory National Ballast Water Management Program for all ships visiting US ports from outside the EEZ, strengthens the provisions of the Great Lakes ballast management program, and establishes minimum requirements for all ships (coastal and transoceanic).[24]

1.3.3.3 Impediments

While the US has initiated steps to intensify legislation and increase capacities to prevent introductions of invasive species, the success of these changes remains to be seen. According to the General Accounting Office (GAO), the National Invasive Species Council’s 2001 management plan, Meeting the Invasive Species Challenge, lacks a clear long-term outcome and quantifiable measures of performance.[25] GAO concluded that while the actions called for in the plan are likely to contribute to controlling invasive species, it is unclear how implementing them will move the US toward a specific outcome, such as a lower number of new invasive species or reduced spread of

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[22] APHIS PPA <http://www.aphis.usda.gov/oa/pubs/qappact.html/>
[23] University of North Carolina Law Library <http://library.law.unc.edu/ocean-coastal/nisa.html>
[24] APHIS NAISA Summary <http://www.aphis.usda.gov/oa/pubs/qappact.html>
[25] GAO-03-1 Invasive Species Oct 2002 Results in Brief

established species. GAO also concluded that the pace of implementation of specific programs is inadequate. As of September 2002, the departments and agencies composing the council had completed less than 20 percent of the actions that the plan had called for by that date. They cite numerous reasons for the slow progress including delays in establishing teams that will be responsible for implementation of the planned actions, the low priority given to implementation by the council, and the lack of funding and staff responsible for accomplishing the tasks.[26]

As the primary agency responsible for implementation of the NISC's plans, USDA APHIS lacks the resources, and sometimes the authority, to adequately prevent the importation of alien pests. For example, APHIS has no oversight of cargo brought in through alternate ports of entry, such as shipments brought in by the Department of Defense, or for goods it does not regulate. Moreover, since 1990 the rapid growth in international trade and travel has dramatically increased the amount of cargo and the number of passengers APHIS must inspect. Policy changes to facilitate trade and customer service have put pressure on APHIS to conduct inspections more quickly to speed the flow of passengers and trade. Despite increased funding and added staff, APHIS is struggling to keep pace with its increased workload. According to APHIS' own estimates, the agency was able to inspect only about 2 percent of all cargo entering the US in 1999 (Byrne, 2000). With only 3,500-4,000 agents working to prevent the entry of alien pests, this is not surprising. Yet, among that 2 percent of cargo, or 1.8 million products, that agents inspected, they found 52,000 pests of concern (Byrne 2000).[27]

1.3.4 International and Regional Agreements and Institutions

There are a number of international and regional agreements and institutions relevant to regulating invasive organisms in the context of trade and the environment. Those at the international level are addressed first as they generally set the context for agreements and institutions specific to North America.[28]

1.3.4.1 International

- **Agreement on Sanitary and Phytosanitary Measures (SPS) –** The World Trade Organization's (WTO) SPS Agreement defines the basic rights and obligations of WTO members regarding use of sanitary and phytosanitary measures to: protect human, animal or plant life or health from the entry, establishment or spread of pests, diseases, disease carrying organisms; and prevent or limit other damage from the entry, establishment or spread of pests. Members can take measures to the extent necessary provided that they are: based on scientific principles; maintained with sufficient scientific evidence; and consider economic factors while minimizing negative trade effects. Members are encouraged to harmonize

[26] GAO-03-1 Invasive Species Background GAO/RCED-00-219
[27] Predicting the Spread, Pam Byrne APHIS 2000
[28] There are a number of other institutions relevant to the control and transport of invasive species whose scope extends beyond the area of agriculture and trade, which include: the Ramsar Convention on Wetlands of International Importance, the International Maritime Organization, the International Civil Aviation Organization and the World Health Organization.

their regulations with international standards (e.g., those developed by the Codex Alimentarius Commission, International Plant Protection Convention [IPPC] or World Animal Health Organization/Office International des Epizooties [OIE]), while higher levels of protection must be scientifically justified. Risk assessments and determination of levels of protection require evaluation of threats by specific organisms, thereby limiting a more general pathway approach targeting a range of species (e.g., softwood packaging material).[29] The article does allow for provisional or emergency measures where scientific evidence is insufficient, however members must pursue additional information for risk assessments and review of the provisional measure.[30]

- **International Plant Protection Convention (IPPC) –** The IPPC is designed to promote measures to control or prevent the spread and introduction of pests of plants and plant products.[31] The SPS Agreement identifies the IPPC as the organization providing international standards for measures to protect plants from harmful pests, which must be scientifically based and not present unjustified barriers to international trade. As such, to the extent Parties adopt measures that are consistent with these standards, the measures are presumed consistent with WTO requirements. IPPC parties can take phytosanitary measures regarding pests and any plant, plant product, storage place, packaging, conveyance, container, soil or other potential carrier of pests. Such measures are to be based on a pest risk analysis, addressing both environmental and economic factors. Standards and guidelines developed to date address areas including: risk analysis, quarantine measures, export certification, reporting, surveillance and integrated measures in a systems approach. The IPPC also promotes collaboration with and through regional plant protection organizations (e.g., the North American Plant Protection Organization).

- **World Organization for Animal Health (*Office International des Epizooties* – OIE) –** Similar to the IPPC, the SPS Agreement identifies the OIE as the recognized international standard setter for issues related to animal health and food safety. These standards and guidelines are designed to: inform states of animal diseases and means to control them; coordinate studies on the surveillance and control of animal diseases; and harmonize regulations for trade in animals and animal products among member states.[32] With regard to the spread of pathogens and invasive species, the OIE has developed a number of tools to prevent the introduction of infectious agents, diseases and pathogens, including: the

[29] Given imperfect information about potential invasives, their impacts and pathways, scientists can rarely predict *ex ante* which species are likely to constitute a threat to agriculture, the environment or public health. Often a species' invasiveness can only be established *ex post facto* after introduction into a member country and damage has occurred.
[30] For an overview of the SPS Agreement and the actual text, see <http://www.wto.org/english/tratop_e/sps_e/spsund_e.htm>. For a critique of the agreement in the context of invasive species, see <http://www.americanlands.org/critique_of_sps_agreement.htm>.
[31] It currently includes 120 contracting Parties and was revised in 1997 in view of the WTO's establishment (although this revised version is not yet in force). See <http://www.ippc.int>.
[32] See <http://www.oie.int>.

International Animal Health Code, the International Aquatic Animal Health Code, the Manual of Standards for Diagnostic Tests and Vaccines, and the Diagnostic Manual for Aquatic Animal Diseases. The OIE also has working groups on biotechnology, informatics and epidemiology, veterinary drug registration and wildlife diseases.

- **Convention on Biological Diversity (CBD) –** The CBD includes invasive species as one of its cross-cutting themes under Article 8 (*In Situ* Conservation), which calls upon parties to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.[33] Additionally, subsequent decisions of the CBD's Conference of the Parties (COP) have recommended development of national invasive species strategies and action plans, and consideration of invasive species within the CBD's major ecosystems types (i.e., forests, marine and coastal regions, inland waters, dry and sub-humid lands, and agricultural biodiversity). The most recent COP adopted, with some controversy, a set of guiding principles on the management of invasives, incorporating a precautionary approach to prevention, eradication and control efforts.[34] Future work is to identify gaps and inconsistencies in the international regulatory framework and to evaluate potential pathways for introduction. Additionally, the Cartagena Protocol on Biosafety was negotiated under the umbrella of the CBD and specifically addresses the safe international transfer of living modified organisms (LMOs).

1.3.4.2 Regional

The US and Canada participate in a wide variety of bilateral and multilateral efforts to share information, conduct research and coordinate their efforts to reduce the threat of invasive species in areas such as agriculture (e.g., bovine, spongiform encephalopathy), shared boundary waters (e.g., ballast water management in the Great Lakes) and other mutual concerns (e.g., West Nile virus). APHIS and CFIA staff meet regularly to discuss these issues. The Canada-U.S. Consultative Committee on Agriculture, established in 1998, also discusses phytosanitary issues, albeit with primary intentions to strengthen trade relations. However, the U.S. and Canada have not developed a comprehensive strategy for joint prevention and management of invasive species. The U.S. and Mexico Consultative Committee on Agriculture, established in 2002, similarly discusses phytosanitary issues, but focuses on improving trade relations. Neither the U.S. and Mexico nor Canada and Mexico have developed a joint strategy for protection against invasive species.

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[33] See <http://www.biodiv.org/programmes/cross-cutting/alien/>.

[34] The guiding principles on alien invasive species include: the precautionary approach; a three-stage hierarchical approach (prevention, eradication, control); the ecosystem approach; the role of States; research and monitoring; education and public awareness; border control and quarantine measures; exchange of information; cooperation, including capacity building; intentional introduction; unintentional introductions; mitigation of impacts; eradication; containment; and control.

Trilaterally, Canada, Mexico and the U.S. have also: signed a memorandum of understanding to establish a North American Animal Health Committee; worked on coordinating responses to particular threats, such as foot-and-mouth disease; and started developing a standard for treating solid wood packing materials (U.S. General Accounting Office 2002).

- **North American Free Trade Agreement (NAFTA) –** Chapter 7 of NAFTA relates to agriculture and sanitary and phytosanitary measures and mirrors some of the provisions within the WTO's SPS Agreement regarding: the right to take sanitary measures to protect human, animal or plant life or health based on scientific principles and risk assessment; avoidance of discriminatory treatment and disguised obstacles to trade; equivalence of domestic standards and regulatory systems; and adaptation to regional conditions. Risk assessments are to be scientifically based considering relevant methodologies, inspection and production methods, and economic factors, and are to minimize negative trade effects. As with the SPS Agreement, a NAFTA country can adopt provisional measures based on available information with a view to conducting further assessments and reviewing the provisional measures. The agreement promotes the use of international standards, specifically recognizing the work of the OIE, IPPC and NAPPO, and establishes a Committee on Sanitary and Phytosanitary Measures.[35]

- **North American Agreement on Environmental Cooperation (NAAEC) –** The NAAEC is the environmental side agreement that was negotiated by Canada, Mexico and the U.S. alongside NAFTA. Article 10.2(h) states that the CEC's Council can develop recommendations regarding alien species that may be harmful. To date the CEC has focused efforts on aquatic invasives by developing a project focusing on marine and aquatic ecosystems designed to:
    - develop a North American Species Information Network and North American hub for the Global Invasive Species Program;
    - create a regional directory of legal and institutional frameworks relevant to the prevention and control of invasive species;
    - identify invasive species and pathways of particular concern and determine actions for state cooperation;
    - develop and distribute tools for raising awareness and empowering policy makers, educators, the public and others; and
    - identify tools to provide economic incentives to industries and private stakeholders for voluntary actions (CEC 2001: 46-8).

- **North American Plant Protection Organization (NAPPO) –** NAPPO is one of the regional plant protection organizations under the IPPC and develops regional phytosanitary standards for implementation by Canada, Mexico and the U.S. through internal regulatory and legislative processes. [36] Particular areas of focus

[35] See NAFTA Articles 712-724, particularly Articles 712 (Basic Rights and Obligations), 713 (International Standards and Standardizing Organizations), 714 (Equivalence), 715 (Risk Assessment and Appropriate Level of Protection) and 717 (Control, Inspection and Approval Procedures).
[36] See <http://www.nappo.org>.

include: plant quarantine, pest risk analysis and pest management techniques. NAPPO works on developing uniform accreditation and training programs to ensure that inspectors within the three countries have a similar technical basis. Additional project areas include: regional standards for phytosanitary measures; standardized procedures for particular pest problems; manuals and training procedures for inspectors; and technical information on survey, regulatory, and pest management procedures. NAPPO has a notification process where a member country notifies the others when an alien plant pest is identified within its borders. NAPPO countries are expected to consult with others in the region before adopting new or modified plant quarantine regulations. NAPPO is recognized within NAFTA as the organization responsible for developing North American phytosanitary standards.

- **IABIN Invasives Information Network (I3N)**[37] **–** The I3N was designed to make country data available in an on-line searchable database, so that government agencies, scientists and land managers could have access to information on the invasiveness of particular species within other countries. A pilot project including thirteen countries was concluded in 2002 and provides initial summary data on invasive species within these countries.[38] A number of other projects are currently under development, including: an internet North American Invasive Species Information Hub; tools to search museum collections in Costa Rica, Mexico and the U.S.; and tools for plotting species distribution and predicting potential invasion sites.

2.0 Case Studies of North American Invasive Species

2.1 Asian Long-horned Beetle

Native to China and Korea, the Asian longhorned beetle (ALB), *Anoplophora glabripennis*, is a destructive wood-boring pest of maples and other hardwoods. The primary pathway for introductions of the ALB into new environments is solid wood packing material (SWPM), although plants, logs and lumber also transport the ALB (APHIS/PPQ ALB Factsheet Dec 2001).[39] Previously undetected in North America, this alien pest was discovered in the United States in New York in 1996, and in Canada in a warehouse in (Waterloo) Ontario in 1998 (Canadian Ministry of Natural Resources Forest Health Alert ALB).[40] Evidence of a possible infestation in Mexico was also

[37] The Inter-American Biodiversity Information Network (IABIN) is an Internet-based forum for technical and scientific cooperation among Western Hemisphere countries to collect, share and use biodiversity information relevant to decision-making and education.
[38] The thirteen countries involved in the pilot project include: Argentina, the Bahamas, Brazil, Chile, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Paraguay, Peru and the U.S. For more information on I3N see <http://www.iabin-us.org/projects/i3n/i3n_project.html>.
[39] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>
[40] Canada's temperate climate is well suited for ALB. During harsh winters, larvae are well insulated within the wood. Following the discovery of the beetle at a Waterloo shipping company in June 1998, the CFIA conducted site inspections at seven other locations where portions of the original shipment were sent. All SWPMs at the shipment locations were destroyed or fumigated. MNR/CFS and the CFIA Forest

found.[41] Since these initial introductions, the ALB has been confined in the U.S. to New York and Chicago, although it has been detected at over 25 warehouses in 14 states (USDA/APHIS Introductions and Warehouse Detections of ALB).[42] It has not spread beyond warehouses in Canada and has not been detected in Mexico.

2.1.1 Origin and Biology

The ALB is found in four climatic zones in China, Japan, and Korea (GISD), indicating that it has broad habitat requirements. Extrapolating from its range in China, the ALB could become established in suitable areas of North America from southern Mexico to the Great Lakes (Haack et all. 1997).

While not unique, ALB habitats are unusual. Most temperate beetles inhabit recently dead or dying wood, but the ALB commonly infests living, healthy, and weakened trees.[43] The ALB attacks many different hardwood tree varieties including Norway, sugar, silver, and red maple, horse chestnut, poplar, willow, elm, and black locust, as well as various fruit tree varieties including cherry, plum, and pear (APHIS ALB Factsheet Jan 2001).[44] Areas that can harbor the ALB include urban (ornamentals), agricultural (windbreaks), rural (shelterbelts, hedgerows), and forests (plantation and natural) (Global Invasive Species Database Ecology of *Anoplophora glabripennis*).[45]

A single female can lay 80 or more eggs individually in the bark of the tree. As they mature, larva feed on the inner wood, chewing banana-shaped tunnels or "galleries" into the wood. These galleries interrupt the flow of water from the roots to the leaves, disrupting the vascillary system of the tree and causing its death (APHIS/PPQ ALB Factsheet Jan 2001).[46]

2.1.2 Pathway

2.1.2.1 Solid Wood Packaging Pathway for ALB

The USDA’s Animal and Plant Health Inspection Service (APHIS) pest risk analysis indicates that the ALB “hitchhiked” to the U.S in SWPM, such as crates, dunnage, and pallets, from China. (APHIS Factsheet Dec 2001).[47] Experts estimate that the ALB might have arrived in New York as much as eight years earlier than when detected. Evidence of early beetle infestation is difficult to identify since ALB attack the smallest and youngest branches of the trees first. The Canadian Food Inspection Agency (CFIA) has determined that entry into Canada was likely via the same pathway (CFIA ALB Factsheet).[48] North American experts have determined that untreated solid wood packing, in particular, provides habitat for wood-boring beetles; synthetic or highly

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Health Monitoring Partnership, Forest Health Alert ALB. <http://mnr.gov.on.ca/MNR/forests/foresthealth/beetle_eng.htm/>

[41] Damage likely caused by ALB has been detected in wooden packaging materials accompanying products from China. <http://www.fao.org/docrep/meeting/x7000e.htm/>

[42] <http://www.aphis.usda.gov/lpa/issues/alb/albmap.html/>

[43] <http://www.exoticforestpests.org/>

[44] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>

[45] <http://www.issg.org/database/species/ecology.asp?si=111&fr=1&sts=/>

[46] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>

[47] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>

[48] <http://www.inspection.gc.ca/english/plaveg/protect/facren/longasia_facrene.shtml>

processed wood materials are not able to harbor wood-boring pests (M. Hicks, Solid Wood Packing Materials, Trade Policy Coordinator).[49]

2.1.2.2 Solid Wood Packaging Pathway Generally

The SWPM material pathway poses considerable risk for introducing many alien forest pests into North America. In addition to ALB, three other wood-boring insects have been traced to importation of SWPM in the U.S. Between August 1995 and March 1998, 97 percent of pests intercepted by APHIS inspectors at U.S. ports and recognized as potential threats to forest resources of the U.S. were associated with SWPM (J. Pasek USDA APHIS, NAPPO PRA Symposium March 2002).[50] Port inspectors recorded 1,205 interceptions of live alien forest pests from SWPM in 1996-1998 (J. Pasek USDA APHIS, NAPPO PRA Symposium March 2002).[51] Other alien pests threaten Canadian forests, such as the Brown spruce longhorned beetle, which is determined to have entered Canada in SWPM in the late 1980s.

The volume and variety of shipments containing SWPM create significant obstacles to preventing introductions of invasives via SWPM. For example, about 100 20-40 ft long containers holding SWPM arrive daily at the port in Long Beach, CA, which receives over 50% of all shipments from China (University of Vermont ALB Site).[52] It is estimated that over one-half of the $1.7 trillion worth of goods that entered or exited the United States in 1999 used some form of SWPM. Since 1991, the Canadian Forestry Inspection Agency (CFIA) has intercepted 47 quarantine pests from 26 countries in random inspections of wood packing arriving with a wide variety of imported cargos (CFIA Wood Packing Material Plant Health Requirements).[53] Over 250 different commodities, such as wire rope, machinery, and stone, are packaged in SWPM (APHIS SWPM from China Interim Rule and request for comments 9/18/98).[54]

Additionally, difficulties in identification, detection, and isolation virtually ensure that many potential invasives associated with SWPM escape detection at ports of entry. First, the presence of SWPM is generally not identified on a shipping manifest, making it difficult for port inspectors to select shipments for inspection. Second, the reuse, reconditioning, or use of foreign materials may conceal the country of origin of the wood – creating difficulties identifying if the SWPM originated in a country that harbors potential invasive species. Third, increasing use of containerized cargo has also made access for inspection more difficult – most imported freight is packed into standardized, boxcar-sized containers for ease of shipping and handling. Inspecting this freight requires costly unloading and reloading of the contents. Consequently, inspections tend to occur only when there is good reason to suspect illegal imports or contamination by potential invasives and only one to five percent of SWPM are inspected at the container tailgate. Finally, even when SWPM is known to have been used, the country of origin is clear, and SWPM is accessible, visual inspections of SWPM are labor intensive and

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[49] <http://www.fas.usda.gov/ffpd/wood-circulars/dec2000tp/solid_wood.pdf>
[50] <http://www.nappo.org/PRA-Symposium/PDF-Final/Pasek.pdf>
[51] <http://www.nappo.org/PRA-Symposium/PDF-Final/Pasek.pdf>
[52] <http://www.uvm.edu/albeetle/>
[53] <http://www.inspection.gc.ca/english/plaveg/protect/dir/d-98-10e.shtml>
[54] <http://www.aphis.usda.gov/oa/chinaswp/hotbutton.html>

inefficient at locating live pests (USDA Pest Risk Assessment for the Importation of Solid Wood Packing Materials into the United States, August 2000).[55]

2.1.3 Impacts

According to APHIS, the ALB has the potential to cause more damage than Dutch elm disease, chestnut blight, and gypsy moths combined, destroying millions of acres of hardwoods (APHIS/PPQ ALB Factsheet Jan 2001).[56] Implications for forest biodiversity and economies of North American countries are significant:

- Damage to Forest Biodiversity: Currently the most effective method of eradicating ALB is to cut, chip, and burn infested trees, replacing them with non-host species that alter the composition and age structure of forests.[57]

- Damage to Agriculture (Windbreaks): Destruction of trees surrounding farm fields increases soil erosion and increases vulnerably of crops to damage from wind, rain, and snow storms etc (Philadelphia Inquirer, "The Riddle of the Beetle" 11/04/2002).[58]

- Economic Damage: In the U.S., the ALB has the potential to damage numerous industries such as lumber, maple syrup, nursery, commercial fruit, and tourism, accumulating over $41 billion in losses annually (APHIS ALB Factsheet Jan 2001).[59] The environmental and economic impact in Canada is similarly significant. Canadian hardwood forests produce approximately $11 billion in wood products annually. Maple trees (*Acer saccharum*), which are a preferred host of Asian Long-Horned Beetle, produce $100 million worth of maple syrup annually. These resources are at risk if Asian Long-Horned Beetle becomes established in Canada (CFIA Regulations for SWPM D-98-10).[60] ALB infestation in Mexican forests could result in environmental and economic hardship.

- Tourism: To the extent forest biodiversity is impacted, tourism can be negatively affected, particularly in fall leaf-viewing areas, and areas with fruit-harvest associated tourism.

2.1.4 Legislative and Regulatory Context

Generally, each of the three countries exempts from regulation wood imported from border states of the other two countries.[61] This exemption is based on an assumption that

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[55] <http://www.aphis.usda.gov/ppq/pra/swpm/>
[56] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>
[57] <http://www.exoticforestpests.org/>
[58] <http://www.philly.com/mld/inquirer/4437861.htm>
[59] <http://www.aphis.usda.gov/ppq/emergencyprograms/longhorn/fact.html>
[60] <http://www.inspection.gc.ca/english/plaveg/protect/dir/d-98-10e.shtml/>
[61] These countries exempt each other from the "bark-free, pest-free" requirements - these imports are still subject to inspection, however.

wood insects in the border states are indigenous to the adjacent North American country or will naturally migrate to that country. This assumption for the U.S. was undermined by a pest risk assessment performed by the Forest Service in 1998, which indicated that several potential pest species with moderate to high risk to U.S. tree resources occur in the bordering states of Mexico but are not present in the U.S. (Tkacz et al. 1998).[62] A 1999 APHIS proposal to impose restrictions on SWPM from all states in Mexico has not been implemented, however.

All three countries require that SWPM and other unmanufactured wood articles be free of bark and live plant pests.[63] If bark is present, the SWPM must be fumigated with methyl bromide, heat treated, kiln dried, or returned before entry.[64] Implementation of the requirement relies on self-declaration of importers. This requirement, unfortunately, is likely inadequate to address pest concerns. In 1999, it was determined that removal of bark was an insufficient measure to ensure against the presence of forest pests.[65] In response to this finding, the U.S. initiated a rulemaking process to amend its regulations.

In response to the more specific threat posed by ALB, APHIS, in 1998, published an interim rule that requires all SWPM from China, including Hong Kong, be heat treated, treated with preservatives, or fumigated prior to arrival in the United States.[66]

The Canadian Food Inspection Agency adopted a similar regulatory directive in 1999, requiring heat or chemical treatment of all solid wood cargo crating from China.[67]

In response to detection of the ALB in the U.S., Canada, Mexico, and the U.S. agreed, in late 1998 and under the auspices of NAPPO, on the elements of a common standard to address risks associated with SWPM. This regional standard has been superceded by an international standard developed and adopted in March 2002 under the auspices of the IPPC. This "pathway" approach for a standard is a departure from the IPPC's usual pest- or country-specific approach. Similar to existing U.S. and Canadian regulations imposed on imports from China and Hong Kong, the standard calls for one of two treatments of SWPM: heating treatment and fumigation using methyl bromide.

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[62] Tkacz, B. M., H.H. Burdsall, Jr., et al. 1998. Pest Risk Assessment of the Importation into the United States of Unprocessed Pinus and Abies logs from Mexico.USDA - FS - FPL - GTR - 104, viii-116 pp.
[63] The U.S. began to regulate importations of logs, lumber, other unmanufactured wood articles, and SWPM in 1995, in response to pest-related risks posed by foreign raw wood. This regulation requires that SWPM imported with nonwood commodities from anywhere in the world except Canada, China, and the border states of Mexico be 100 percent free of bark and be free from live plant pests.
[64] <http://nappo.org/>
[65] An assessment performed by the U.S. determined that deep wood-boring plant pests and other types of exotic plant pests, such as pathogenic fungi, can remain even after removal of the bark
[66] 7 C.F.R. § 319.40.
[67] <http://www.inspection.gc.ca/english/plaveg/protect/dir/d-98-10e.shtml/> D-98-10 requires that all shipments containing solid wood crating must be accompanied by an official certificate from Chinese authorities confirming that it has been heat or chemically treated.
These regulations are for all non-manufactured wood dunnage, crating and other wood materials used for or with shipping originating in China and HKSAR. D-98-08 (Plant Health and Production Division Directive on Import Requirements for Wood Dunnage, Pallets, Crating or Other Wood Packaging Materials) remains in effect for all other countries of origin. All manufactured wood used as dunnage, pallets, crating or other packaging materials, as well as wood particles such as sawdust or wood shavings, used as packaging materials, are exempt.

Parties to the IPPC are urged to accept SWPM that has undergone one of the two treatments "without further requirements except where interception and/or [risk assessment] show that specific quarantine pests associated with certain types of wood packaging…from specific sources require more rigorous measures." As one expert notes, this appeal appears to thrust countries back into regulating SWPM piecemeal, and by labor-intensive inspections, instead of as a pathway. Additionally, the standard exempts from regulation certain types of wood packaging that may pose pest threats, including loose wood packing such as sawdust and shavings, and raw wood cut into thin pieces.

Building on the rulemaking process initiated in 1999, APHIS has drafted new regulations to implement the standard and is proceeding with development of an environmental impact statement, in which alternatives under consideration range from no action to requiring the use of alternative materials[68] Canada and Mexico are also proceeding to implement the new standard.

The US and Canada participate in a wide variety of bilateral and multilateral efforts to share information, conduct research, and coordinate their efforts to reduce the threat of invasive species. APHIS and CFIA staff meet regularly to discuss these issues. The Canada-U.S. Consultative Committee on Agriculture, established in 1998, also discusses phytosanitary issues, albeit with primary intentions to strengthen trade relations. However, the U.S. and Canada have not developed a comprehensive strategy for joint prevention and management of invasive species. The U.S. and Mexico Consultative Committee on Agriculture, established in 2002, similarly discusses phytosanitary issues with a focus on improving trade relations.[69] Neither the U.S. and Mexico nor Canada and Mexico have developed a joint strategy for protection against invasive species.

Regulations adopted by the U.S. and Canada toward China and Hong Kong and advanced by the IPPC international standard, that all unmanufactured wood be heat treated or fumigated, have greatly reduced, and will likely continue to reduce, introduction of wood pests to North America. However, they have been the subject of much criticism as well. Most significantly, their dependence on methyl bromide raises health and environment concerns. Methyl bromide is categorized as an extremely acute toxic by the U.S. EPA.[70] Moreover, it significantly contributes to depletion of the ozone layer. The 149 member nations to the Montreal Protocol agreed to ban methyl bromide in industrialized countries by 2005 and in developing countries by 2010, but made an exception for its use as a phytosanitary measure.[71] Experts familiar with negotiations that produced this exception say it was agreed to based on the mistaken belief that use of methyl bromide for phytosanitary purposes would be limited relative to its other uses.

Additionally, the failure to require use of alternatives to SWPM leaves doubts that efforts to prevent introduction of ALB will succeed. Critics of the regulations note that determining the origin and history of most SWPM in use is impossible given that it is

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[68] The Phytosanitary Standards are contained in the International Plant Protection Convention's IPPC "Guidelines for Regulating Wood Packaging Material in International Trade".
[69] Consultative Committee on Agriculture Action Plan, Terms of Reference <http://www.iir.gov.ab.ca/trade/media/CCA_terms_reference.pdf>
[70] EPA Hazard Summary Methyl Bromide <http://www.epa.gov/ttnatw01/hlthef/methylbr.html>
[71] Faith Campbell, personal communication with Anne Perrault, 2/7/03.

exchanged among shippers, importers and exporters and its origin sometimes falsified. Additionally, inspectors have reported finding pests on SWPM that meet regulations, indicating that the requirements do not ensure the absence of invasives.[72]

2.1.5 Levels of Trade

In recent years, increased international trade has resulted in a corresponding increase in the amount of untreated solid wood packing materials entering North America. In the last 15 years, North American countries have broadened their trade partners, especially with the Pacific Rim and Asia. Trade with China has increased tremendously to $62 billion annually, which is up from $5 billion in 1985. As a result, the volume of pallets and crates passing through ports of entry has grown exponentially.

2.1.6 Recommendations

- Require the use of materials other than wood to reduce the threat of introductions, reduce threats posed by use of methyl bromide, and minimize the need for inspections. Experience indicates that wood is much more likely than synthetic materials, such as plastic, to harbor invasive species. Experience also reflects that capacity to inspect solid wood packing materials is very limited; it is impossible to inspect all or even more than a slight percentage of goods or shipments of goods. Moreover, inspections often fail to detect eggs or pre-adult life stages. Requiring use of alternative materials will significantly reduce risk of introduction of invasive species, while reducing harm posed by methyl bromide.

- Ensure that those responsible for developing and using solid wood packing materials are motivated to reduce risks they pose of introduction of invasive alien species. Since the capacity to prevent introductions of invasive species is so limited, it is essential to encourage proactive measures to reduce risks. One option is to consider user fees tied to risk (see Perrault and Carroll, 2002).

- Adopt existing international standard for solid wood packing, but simultaneously provide deadline by which time all goods coming into N. America must be in packaging made from other than solid wood, including fiber board, plastic, metal, etc.

- Recognize and regulate all sources of wood pests, including those associated with wood chips, logs and lumber etc.

- Recognize and respond to costs associated with use of solid wood packing. Evidence indicates that we are paying a significant price for convenience of solid wood packing. A more cost effective and useful approach would be use of plastic crates.

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[72] For example, at the NAPPO Forestry Panel meeting in April 2000 Canada expressed concern that more than 30 incidents of methyl bromide treated shipments from China were found to contain live insects.

2.2 Plum Pox Virus

Plum pox virus (PPV), also known as sharka, is the collective name for a group of devastating viral diseases of stone fruits (*Prunus* species) including peaches, apricots, plums, nectarines, almonds and cherries.[73] The disease significantly limits stone fruit production in most areas where it has become established, including large parts of Europe, the Mediterranean, the Middle East (Egypt and Syria), India and Chile (APHIS PPV Factsheet).[74]

In North America it was first detected in Pennsylvania in 1998, where it most likely was introduced through infected propagation material, although the specific pathway and country of origin are unknown (APHIS PPQ Factsheet).[75] It was detected in Ontario, Canada in 2000, and has not been detected in Mexico.[76] Currently, it has been contained in the U.S. and Canada.

2.2.1 Origin & Biology

PPV has been a well-known pathogen of stone fruits for over sixty years in Europe where it is considered to be one of the most important diseases limiting production (Gidlow, F. et al. 2000).[77] Four major strains of PPV occur, but only one – PPV-D – has been established in North America.[78] The virus interferes with normal plant functions, resulting in disease symptoms that are frequently very diagnostic and easily recognized. These symptoms include irregular depressions and chlorotic or yellow ring spots on fruits and chlorotic vein clearing or ringspots on leaves. The fruit is also fibrous and lacking in flavor, and may drop prematurely causing total crop loss. Unfortunately, many trees fail to show symptoms for the first few years following the initial infection of the tree. The lack of symptoms cannot be relied upon as proof that a plant does not have the disease (Gidlow, F. et al. 2000).[79]

PPV was first identified in the Western Hemisphere in 1992, in the stone fruits of Chile (Penn State PPV Factsheet).[80] Testing for stone fruit viruses in the U.S. and Canada did not include tests for PPV until after it was detected in the U.S. in 1999 (Penn State PPV Factsheet).[81] It undoubtedly was introduced in the U.S. and Canada several years before it was detected.

2.2.2 Pathway

The specific pathway and country of origin from which PPV spread into N. America are still unknown at this time. However, it was almost certainly brought into N. America by

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[73] Plant viruses are named according to the plant host in which they are first identified, hence the name plum pox virus or PPV. The name, however, does not indicate its complete plant host range.
[74] <http://www.aphis.usda.gov/ppq/plumpox/plumpoxfs.pdf>
[75] <http://www.aphis.usda.gov/ppq/ep/plumpox/background.html>
[76] Personal communication of Mario Fuenteraya (Sagarpa) with Morgan Bennett, 2/18/03.
[77] Pennsylvania State Dept of Plant Pathology <http://pubs.cas.psu.edu/FreePubs/pdfs/ul204.pdf>
[78] Authorities in the U.S. and Canada are concerned about the possible introduction of the M strain from France and possibly elsewhere in Europe (impact to wild cherry).
[79] Pennsylvania State Dept of Plant Pathology <http://pubs.cas.psu.edu/FreePubs/pdfs/ul204.pdf>
[80] <http://sharka.cas.psu.edu/review_update.htm/>
[81] <http://sharka.cas.psu.edu/review_update.htm/>

humans through infected propagation material (APHIS PPV Background).[82] Experts have identified with certainty only two types of vectors of plum pox virus: aphids and humans (Penn State PPV Factsheet Feb 2001).[83] Winged aphids that feed on plants by sucking cell sap are the only natural means of PPV transmission within an orchard and are responsible for the short range proliferation of PPV from tree to tree or to nearby orchards. However, aphids can transmit the virus for only a short time after acquiring it, varying from minutes to hours, and an aphid loses the ability to spread the virus after it probes a plant that is not a PPV host. Human-mediated transport of PPV-infected nursery stock, propagative materials, or, possibly, commercial fruit, is the only possible way PPV could have bypassed natural barriers such as mountain ranges, forests or oceans to spread through Europe and to establish in North America.[84]

Additional threats posed by nursery stock pathway

It has been estimated that since the late 1800s in the U.S., more than a half dozen of the most damaging forest pests have been introduced on imported nursery stock, including chestnut blight, white pine blister rust, balsam woolly adelgid, beech scale, dogwood anthracnose, Port-Orford-cedar root disease, and probably butternut canker.[85] Nursery stock-mediated invasives such as the Glassy-winged sharpshooter, (*Homalodisca coagulate*), significantly impact crops and forests of Mexico and the U.S. Canada faces similar threats, including those posed by the Hemlock Woolly Adelgid (*Adelges tsugae*), Oak Wilt (*Ceratocystis fagacearum*), Bacterial Canker of Poplar, and Sudden Oak Death *(Phytophthora ramorum*), all on Canada's "ten least wanted" forest pests list.[86]

2.2.3 Impacts

Establishment of PPV can result in the following significant impacts:

- Economic: PPV causes fruit to be unmarketable and decreases the yields of PPV-infected trees.
- Economic/Environmental: Eradication requires that all infected trees be destroyed. Any single PPV-infected stone fruit tree remaining in the area will act as a virus reservoir for future aphid spread to additional trees. Unless every infected tree is eliminated immediately upon discovery, PPV epidemics can reoccur within a few years (Penn State PPV Factsheet).[87]
- Biological: The presence of PPV can enhance the effects of other endemic viruses infecting various *Prunus* species, such as prune dwarf virus, *Prunus* necrotic

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[82] <http://www.aphis.usda.gov/ppq/ep/plumpox/background.html>
[83] Evidence of seed transmission exists, but is highly questionable and needs to be verified. <http://sharka.cas.psu.edu/review_update.htm/>
[84] Research this past year by Gerard Labonne and Jean-Bernard Quiot in France provides evidence for a potential role of fruit in PPV spread. Whether this type of transmission plays a major role in PPV spread over long distances by transport or imports of infected fruits is not known at this time. However, the possibility and the danger clearly exist. <http://sharka.cas.psu.edu/review_update.htm/>
[85] American Lands Alliance, <http://www.americanlands.org/plants_as_vectors.htm/>
[86] <http://www.inspection.gc.ca/english/plaveg/for/images/leaste.pdf>
[87] <http://sharka.cas.psu.edu/review_update.htm/>

ringspot virus, and apple chlorotic leaf spot virus (APHIS Emergency Program PPV).[88]

The impact of PPV in North America, however, has, thus far, been limited. The U.S. and Canada have addressed PPV infections by quarantining infected areas, eliminating infected trees, and increasing border inspections of nursery stock in an attempt to prevent future introductions. When PPV was detected in Pennsylvania in 1999, the Pennsylvania Department of Agriculture (PDA) prohibited movement of stone fruit seedlings and budwood out of infected areas (two townships) and orchards containing infected trees were destroyed and burned (almost 900 acres). In 2000, a national survey supported in part by USDA-APHIS and conducted by several states (mostly CA, GA, OR, SC and WA) failed to detect PPV in other major stone fruit growing regions of the US (APHIS Emergency Program PPV).[89]

PPV was first detected in Canada as a result of a PPV outbreak throughout Ontario. Budwood from PPV-infected cling peach cultivars had been selected by an Ontario nursery for seedling production and the resulting infected seedlings were shipped to several locations throughout Ontario, over a distance of 250 km. How PPV entered Canada and where it originated is also unknown. Currently, Canadian growers and government regulatory agencies are working to eradicate PPV from Canada. Over 13,000 PPV-infected fruit trees have been removed from all infected sites, and quarantine zones and buffer zones around infected areas have been established (CFIA PPV Factsheet).[90]

2.2.4 Legislative and Regulatory Content

2.2.4.1 Canada

The Plant Protection Act is the primary law governing import of plants into Canada.[91] The Act details that imported items are subject to inspection and regulation. After PPV was detected in the U.S., the CFIA suspended importation of *Prunus* plant materials from the U.S.[92] Additionally, all *Prunus* material (including nursery trees, scionwood and rootstock) imported from Pennsylvania in the preceding three years were placed under quarantine and further surveys were conducted. Despite these efforts, PPV was confirmed in Canada in June of 2000.[93] The CFIA initiated a PPV Emergency Program to determine the extent of the infection and take action to control its spread.

Canada has designated PPV a "quarantine pest".[94] Under the general import requirements for plants and plant parts for planting from all countries, shipments of plants

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88 <http://www.aphis.usda.gov/ppq/ep/plumpox/faq.html/>
89 <http://www.aphis.usda.gov/ppq/ep/plumpox/index.html>
90 <http://www.inspection.gc.ca/english/plaveg/hort/ppv/infoe.shtml>
91 It is intended to "to prevent the importation, exportation and spread of pests injurious to plants and to provide for their control and eradication and for the certification of plants and other things."
92 <http://inspection.gc.ca/english/corpaffr/newcom/1999/19991122e.shtml/>
93 <http://inspection.gc.ca/english/corpaffr/newcom/2000/20000623e.shtml/>
94 Canada adopted IPPC definition of quarantine pest – "A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled." (FAO, 1990; revised FAO, 1995; IPPC 1997)

to Canada must be free of quarantine pests.[95] Several commodities, including fresh fruit and cut flowers, are exempted from quarantine pest regulation. Greenhouse plants from the United States (US) imported under the Greenhouse Certification Program by a designated facility are covered under a separate regulation.[96] Additionally, Canada implemented a regulation specific to PPV, prohibiting *Prunus* branches for decorative purposes from Countries where PPV is established.[97]

2.2.4.2 Mexico

Mexico has implemented a law to prevent introduction of viruses that affect plants and to harmonize its efforts with international phytosanitary standards. Basically, if a pest risk assessment indicates that a good is "low" risk, the good is visually inspected only. If the good is deemed "high" risk, it is subject to mitigation measures.[98] Regulations exist for specific items, including nursery stock, fruits and cut flowers. To be imported into Mexico, certain plants from the U.S. must be free of viruses, including plum pox virus.[99] Other regulations describe phytosanitary measures to be taken if plum pox is established in Mexico.[100]

2.2.4.3 U.S.

The Plant Protection Act is the basic law governing import of plant products into the U.S.[101] Following the identification of PPV-D in Pennsylvania, APHIS worked with state agencies to eradicate PPV-infected trees and implement quarantine measures for the area.[102] In March of 2000, the Plum Pox Emergency Program was established to coordinate a response to PPV entry into the US and conduct a national search for PPV.

National regulations restricting import of certain plant materials were amended to restrict importation of certain *Prunus* plants and plant parts.[103] Restricted plant materials

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[95] CFIA. Plant Protection Import Requirements for Rooted, or Unrooted Plants, Plant Parts, and Plants *In Vitro* for Planting. Available at www.inspection.gc.ca/english/plaveg/protect/dir/directe.shtml . The CFIA is moving to prior approval for all off-continent material in the future.

[96] D-99-07. Interim Policy for Importation from the United States and Domestic Movement of Plum Pox Virus (PPV) susceptible *Prunus* Propagative Plant Material

[97] D-00-02. The Prohibition of *Prunus* Branches for Decorative Purposes from Countries where the Plum Pox Virus Occurs

[98] Article 7, Section 18, focuses on preventing introduction of viruses that affect plants. Section 3 requires harmonization with international phytosanitary standards.

[99] EUA147 (under NOM-007-FITO-1995)

[100] O/CAP de 15.10.1984 (DOGV nº 200, de 5.11.1984). Declaración existencia Sharka.
O/CAPA de 5.6.2000 (DOGV nº 3.776, de 21.6.2000). Medidas fitosanitarias para plantaciones de frutales afectadas por el virus de la Sharka y concesión de ayudas por arranque de árboles afectados.

[101] See Section 1.3.3, above. The PPA gives the Secretary of Agriculture the ability to prohibit or restrict imports, exports, or interstate movements of plants, plant pests, noxious weeds, and biological control organisms.

[102] 7 CFR 301.74

[103] Including almond, apricot, cherry, cherry laurel, English laurel, nectarine, peach, plum, and prune plants. 7CFR319.37-5 Nursery Stock, Plants, Roots, Bulbs, Seeds, and other Plant Products Regulation details foreign inspection and certification requirements for certain plant materials from certain countries.

grown in specified European countries are required to be free of plum pox virus, as certified by the plant protection service of the country of origin.

Experts dealing with plant introductions recently developed "Voluntary Codes of Conduct "designed "to curb the use and distribution of invasive plant species through self-governance and self-regulation by the government, nursery professional, gardening public, landscape architects, and botanic gardens and aboreta."[104]

2.2.4.4 North American Plant Protection Organization

Under the auspices of the North American Plant Protection Organization, the U.S., Canada and Mexico are developing "Guidelines for regulatory action following detection of plum pox virus in NAPPO member countries". The document is focused on actions taken after detecting PPV and on the FAO standards for Pest Free Areas (PFA), Pest Free Places of Production (PFPP) and Pest Free Production Sites (PFPS) as potential alternative phytosanitary options. Generally, the guidelines are intended to facilitate trade in PPV susceptible plants for planting and propagation. Additionally, the Forestry Panel and Fruit Tree and Grapevine Panels are meeting in February 2003 to begin documenting the risk of pest introduction via plant imports and developing a N. American guideline intended to close this pathway (Campbell 2003).

2.2.5 Levels of Trade

U.S. plant imports rose from 456 million plants in 1993 to more than 694 million plants in 1999.[105] Not only are the numbers increasing, the increasing variety of plants imported from a wider variety of countries raises the variety of pests that could be introduced; by 2000, the U.S. was importing 863 genera of plants.[106]

2.2.6 Recommendations

- Ensure that invasiveness of nursery stock is assessed prior to entry of materials using emerging risk assessment methods that consider plant characteristics and prior observations or experience with the plant elsewhere in the world. Experts in the U.S. advocate this recommendation in the "Voluntary Codes of Conduct". Given that PPV had already established in Chile before it was introduced into the U.S. or Canada, it may have been possible to prevent these introductions had an assessment of threat posed by *Prunus* species been made based on prior observations elsewhere in the world.
- Develop a joint strategy for preventing importation of invasive nursery stock. The U.S., Canada, and Mexico, should not only discuss actions each are taking to prevent introduction of invasive plant pests via nursery stock, but should, also,

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[104] "Draft Voluntary Codes of Conduct" were adopted at a meeting in St. Louis in March 2002. A "St. Louis Declaration" accompanied release of the Codes of Conduct. http://www.mobot.org/iss/press_release2.htm

[105] APHIS Federal Register July 23, 2001 (Volume 66, Number 141)

[106] Megan Thomas, APHIS, personal communication with Faith Campbell, American Lands Alliance.

work together to develop a joint strategy to prevent these introductions. Such a strategy could include a system for monitoring and quaranting nursery stock, developing and exchanging information and technology – including testing standards, certification systems, etc.

- Ensure that pathway actors introducing nursery stock assume responsibility for risks they pose. This might include requiring testing of nursery stock prior to export, paying a "user" fee tied to risk to encourage pathway actors to reduce risk, etc.

2.3 GM Maize

In mid-2001, researchers from the University of California at Berkeley working in remote areas of Mexico claimed to have identified traces of genetically modified (GM) maize within traditional landraces farmed by local communities. The findings generated a storm of debate over their accuracy as well as the potential impacts on agricultural biodiversity and local livelihoods in the region where maize agriculture originated. The incident has contributed to a growing number of questions about the regulation of biotechnology products, specifically with regard to their intended use for human consumption, animal feed and/or planting.[107]

Mexico is the center of origin for maize (*Zea mays spp. mays*), which originated over 7,000 years ago. The country currently holds over forty different racial complexes of maize and recognizes several thousand varieties. Through this bounty, Mexico manages a range of maize varieties and wild landraces (called teosintes – *Zea mays spp. parviglumis*) that are recognized as important for agricultural diversity and world food security.[108] Mexican germplasm has been instrumental in improving maize varieties particularly for use in tropical regions and high altitudes to decrease growth cycles and increase yields, resistance to pests and drought, and protein content. Mexican varieties and their derivatives have been used in developing improved populations of maize for over forty countries in Latin America, Africa and Asia (Nadal 2001: 1).

As novel genetic organisms introduced into an ecosystem where they did not evolve, living or viable GMOs share many of the traits and potential impacts of other alien and potentially invasive species. The U.S. National Invasives Species Council defines an invasive species as a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Council 2001: 2). In this case, the variety(s) of GM maize introduced is certainly not native to Mexico thereby fulfilling the first criteria. Regarding the second criteria, scientific studies are currently underway to evaluate potential adverse effects and the extent of these impacts

[107] The incident follows upon the Starlink episode of 2000, where GM maize approved solely for animal consumption was found on grocery store shelves. The findings resulted in a large-scale recall of corn products, impacted U.S. maize exports most especially to Asia and raised fundamental questions regarding the U.S.'s ability to regulate and segregate GMOs intended for different end uses.

[108] The distribution of teosinte generally extends through the southern part of the Mexican region known as Arid America (located in the Western Sierra Madre and the Guadiana Valley) to the Guatemalan border (Sánchez González 1995: 19).

on local landraces and varieties of maize.[109] Given that the extent of any adverse impacts has yet to be scientifically determined, the following case study will look at potential dangers of GM maize as an invasive species, and the mechanisms available to address those dangers.

2.3.1 Origin and Biology

Transgenic plants were first developed in the early 1980s by teams of researchers working at Washington University, the University of Wisconsin, Monsanto and Rijksuniversiteit in Belgium. Initial work was performed on tobacco and sunflower plants, however once the process for introducing genes into other species was established experimentation increased rapidly. Varieties of Bt maize were developed to protect plants against the European corn borer, corn earworm and Southwestern corn borer. Bt maize was first developed for commercial purposes in the U.S. and first planted for harvest in 1996.[110] During the 2000-2001 period, world maize production (584.0 million metric tons) ranked second in major staple crops between wheat (587.0 million metric tons) and rice (397.7 million metric tons), and will likely exceed wheat production for 2002-2003.[111] Only eight countries produced GM maize in 2000, however these countries comprised 85% of the global maize market, exporting to 168 countries (Phillips 2003).

Maize is the main staple food in Mexico's diet, representing the largest area of cultivated land and the second largest crop in terms overall gross production volume.[112] Although the contribution of agricultural production generally, and maize production more specifically, to the economy has steadily decreased (agriculture accounted for the less the seven percent of Mexico's GDP in 1998, the agricultural sector still maintains over 20% of the work force, most of whom are engaged in maize production. Of these 2.5 to 3 million mostly rural producers, an estimated 60% use locally adapted maize varieties encompassing up to 80% of the total area used for cultivating maize (Nadal September 2000: 5, 11). However, a significant element depressing the value of maize production has been the Mexican government's efforts to keep prices low for consumers, which has ultimately resulted in a 50% price reduction from 1995 to 2000.

Maize, unlike other cereals such as wheat or rice, is an open pollinating crop which means that in reproduction neighboring plants exchange genetic material. Thus,

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[109] Of particular note, the CEC has initiated a Chapter 13 investigation into the case of GM maize in Mexico. To date an advisory committee has been established, terms of reference for a report to the CEC Council have been drafted and four background papers were posted on the CEC web site in January 2003. The background papers include: Miguel Altieri, "Socio-cultural Aspects of Native Maize Diversity;" Elena Alvarez-Buylla, "Ecological and Biological Aspects of the Impacts of Trangenic Maize, including Agro-biodiversity;" Chantal Line Carpentier and Hans Herrmann, "Maize and Biodiversity: The Effects of Transgenic Maize in Mexico – Issues Summary;" and Scott Vaughan, "Economic Valuation and Trade-related Issues." They can be downloaded from <http://www.cec.org/maize/index.cfm?varlan=english>.

[110] See information on transgenic crops available at <http://www.colostate.edu/programs/lifesciences/TransgenicCrops/current.html>.

[111] Future demand for maize in developing countries is expected to surpass that for both wheat and maize by 2020. Most of this demand stems from rapid growth in poultry and livestock consumption and the consequent need for animal feed (Pinghali 2001: 1; and USDA December 2002).

[112] From the period 1997-99, over 70% of the total area devoted to cereals in Mexico was used for maize production. By comparison, the corresponding figure for the U.S. was 47% and Canada 6% (Pingali 2001: 48-53).

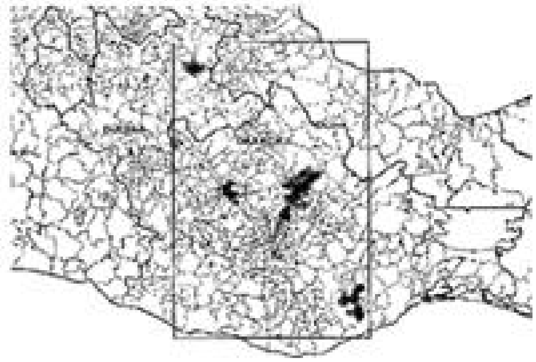
depending on the existent varieties in a field, successive generations can vary genetically from earlier ones. This cross-fertilization of maize allows for the selective development of physical characteristics such as increased size and yield, a quality which is especially useful for manipulation by plant breeders.[113] Additionally of the cereals, maize (i.e., its grain, leaves, stalks, tassels, roots) has the largest number of applications ranging from human and animal consumption, industrial application and cultural usages. It also is the world's most widely grown cereal across a range of natural environments (e.g., high/low altitudes, tropical/temperate climates, rich/poor quality soils, seasonal variations). These factors further contribute to the development of different varieties to maximize crop health and yield for diverse growing conditions and applications. In many rural areas of Mexico, local communities farm a number of different varieties of maize (often up to eight varieties in one field) to protect against potential environmental and pest hazards, as well as to produce specific varieties for dietary and cultural purposes (Nadal 2001: 9). This ability to combine different seed varieties and dates of sowing has been considered one of the best technological resources for traditional farmers (CEC 1999: 86).

2.3.2 Pathway

Initial evidence of GM introgression in native landraces was first discovered in early to mid-2001 and later published by Quist and Chapela in November 2001. After questions of methodology and validity of the initial findings arose, subsequent studies by Quist and Chapela as well as by Mexican authorities, including SEMARNAT, Conabio and the National Institute of Ecology (*Instituto Nacional de Ecologia* – INE), found that transgenes are present in landraces around the areas of Oaxaca and Puebla (INE September 2001).[114] In this study, seeds from 22 locations were tested with no evidence of contamination at eleven sites (around Valle de Tehuacan in Puebla and Sierra Norte de Oaxaca), evidence of transgenes in 3-13% of samples at seven sites (around Valle de Tehuacan in Puebla and Sierra Norte de Oaxaca) and evidence of transgenes in 20-60% of samples at four sites (around Ixtepeji, Tlalistac, Nochistlan and Santa Maria Ecatepec). Additionally, samples of unprocessed maize taken from a Disconsa store showed that 37% of samples had evidence of transgenes (INE and Conabio 2001). The INE has continued the testing, but has not released any subsequent findings.

Map of Sites with Evidence of Transgenic Maize

[113] Self-pollinating crops, such as wheat and rice by definition use their own genetic material for propagation, which generally ensures that successive generations will retain the essential genetic identity of preceding generations (Pingali 2001: 26).
[114] For more detail on the scientific debate see: Quist November 2001; Metz April 2002; Kaplinsky April 2002; and Quist April 2002.



(INE and Conabio 2001)

While Mexico has maintained a ban on planting GM maize since 1998, the country is a major importer of maize. The United States is the world's largest producer and exporter of maize, and sells over 90% of this to Mexico and the rest of Latin America.[115] This is due to a combination of a *de facto* ban by the European Union on imports of GM maize and decreased tariffs on maize exports to Mexico under NAFTA. Within US exports, GM varieties are generally co-mingled with non-GM varieties intended for both domestic consumption and export markets. Of the GM maize varieties under cultivation, most are modified versions of Bt maize, which is genetically engineered to produce a protein, using a gene from the bacterium *Bacillus thuringiensis* (Bt), that is toxic to certain insects.

The most likely source of GM maize for the areas of contamination came from rural stores that sell grain imported from the U.S. to local consumers and farmers. Authorities assume that some of this GM maize, which was intended for consumption, was actually planted by locals following their customary practice of saving and trading seed for future cultivation (CIMMYT December 2002). Subsequent sampling of maize from government subsidized *Diconsa* stores in the city of Capulalpam tested positive for GMOs. The purchase cost of maize in these stores is reportedly one-third lower in cost per kilogram than the costs involved in growing one's own varieties (Cummings 2002: 10, 14). These subsidized prices compared to prices of other varieties on the market are often a further incentive for local growers to experiment with purchased seeds.

Without a record of varieties of GM maize imported into Mexico, it is extremely difficult to identify the initial source variety. Identification becomes even harder if such trans-genes are from experimental varieties which have not been commercialized and for which there is little publicly available information. Given that the exact variety of GM maize has not been identified, the possibility remains that the maize came from plants not intended for human consumption or that were used to express industrial or pharmaceutical biochemicals. In such cases, introgression of these particular traits could be particularly hazardous to human health.[116] However, given that the assumed source of seed was from imports specifically designated for consumption, such concerns, while hypothetically possible, should be viewed as minimal.

[115] This high level of exports to Latin America is coincident with a recent decrease by 70% in exports of U.S. corn to Europe, given their de facto restrictions on the import of GM food products (Phillips 2003: 2).
[116] Different applications for "bio-pharming" include anti-biotics to prevent diarrhea in pigs and contraceptive anti-bodies that kill human sperm.

In contrast to the invasions discussed above, “invasion” by GM maize occurs at the genetic level through the process of gene flow within the plant’s reproductive cycle. Gene flow is especially prominent in maize given its open-pollinating nature, and such introgression of traits from one maize variety into another has been occurring naturally for generations. Thus, it is difficult to keep one variety of maize genetically isolated from other nearby varieties, and gene flow among native varieties of maize and commercial hybrids has been long documented in Mexico.

However, such gene flow has historically been intraspecific – that is between one variety of maize and another. By contrast, the introduction of GM crops raises the possibility of introducing transgenes (genes from another species) into existing varieties.[117] As Alvarez-Buylla writes: “once transgenic varieties grow in proximity to local and cultivated varieties, gene flow and introgression of transgenes into these local varieties is expected. Furthermore, the individual teosinte and maize plants that carry newly introgressed transgenes can function as natural bridges for introgression into other varieties” (Alvarez-Buylla 2002: ii). Additionally, traditional practices of saving and trading seed could lead to a much larger spread of GM maize in Mexico than might be expected if gene flow occurred only via natural pollination.[118]

2.3.3 Potential Impacts

GM maize can cross-breed or lead to gene flow into wild landraces of maize, as well as other maize hybrids. Many of these varieties are the result of traditional agricultural practices by the area’s indigenous communities for personal consumption and animal fodder. Experts have identified 41 racial complexes, while modern improved varieties of maize represent almost one quarter of Mexico’s diversity of local maize races. The key unknown is the extent and duration of any impacts from GM introgression into these varieties.

The permanence of a transgene within another landrace or variety of maize depends on whether it improves or decreases the plant’s overall fitness. As with natural selection, improved fitness will tend to increase the transgene’s prominence until permanently fixed. Decreased fitness would generally contribute to the transgene’s decrease within a population. If the transgene was neutral in effect, its permanence would depend on frequency of gene flow and other stochastic factors.[119]

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[117] Recent studies within the U.K. on rapeseed have confirmed inter-species gene flow between GM and non-GM varieties of rapeseed that were grown in relative proximity (Norris 2002).

[118] For a discussion of the cultural importance of seed exchange among local farmers, see Louette 1995.

[119] According to the International Maize and Wheat Improvement Center (CIMMYT), “Tracking the effects of environmental selection is relatively straightforward compared to assessing the impact of farmer management practices. If the transgene confers a trait that works against the survival of the plant, plants carrying that gene will be eliminated from the gene pool through natural selection. If there is no environmental selection pressure acting on the gene (for example, if no stem borers, which are the target of the Bt biopesticide, are present to act on maize carrying the Bt gene), population genetics models indicate that the gene will be fixed at the frequency at which it was introduced, or it will be lost over time. Finally, if the gene confers a selective advantage, it will increase and spread through the population. Again, since the transgenic maize varieties now being commercially grown use single-gene traits, in none of these cases should overall genetic diversity be decreased. There are implications, however, for the rate of diffusion (or conversely, containment) of transgenes.”

To date little data has been found to verify concrete impacts of the introduction of GM varieties and gene flow into area landraces. However, laboratory experiments and field experiences in other cases suggest a range of potential threats posed by introgression of the Bt transgene, including:

- **Weed evolution:** In some cases, teosintes are regarded as weeds in areas where maize is harvested, and are therefore controlled by herbicides or naturally by pests. If gene flow conveyed Bt resistance to those weedy varieties, then the teosintes could develop increased resistance to particular herbicides and pests, making them harder to control.

- **Genetic erosion:** In cases where a newly introduced gene and its corresponding trait become fixed, there is the potential for replacement of the original gene within the same genetic position. While this occurrence is rare in open-pollinated species like maize, there is the potential that these wild genes and their corresponding diversity could be permanently lost. Genetic erosion can lead to the vulnerability and extinction of races and even species of maize, and once lost a genotype is irretrievable. Crop diversity of primitive varieties is essential for maintaining genes with attributes for withstanding natural elements and pests, and increasing nutritional value.[120]

- **Evolution of resistant insects and new pests:** In cases where pests are exposed to herbicides such as Bt over an extended period of time, there is the potential for them to develop immunity to that herbicide over subsequent generations. Studies have also shown that Bt toxins can remain in the soil and bio-mass for extended periods of time with potential consequences on soil biota and nutrient cycling processes. While modern agriculture has developed a number of practices to minimize such long-term exposure, these techniques may not be a practical solution within the context of small-scale or subsistence agriculture in Mexico.[121]

- **Unexpected ecological effects:** Finally, the unintentional introgression of transgenes into plants may have unexpected effects on other organisms within the

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CIMMYT goes on to analyze the potential for introgression of genes from transgenic maize into wild relatives, such as tripsacum and teosinte. For tripsacum, introgression would be difficult given past research and efforts on developing hybrids, although introgression into teosinte would be more likely (CIMMYT May 2002).

[120] Aside from the potential introduction of transgenes, genetic erosion of Mexico's traditional varieties of maize may also be occurring from social and economic causes. Much of maize's genetic diversity is fostered by local communities maintaining their traditional practices. However, falling prices of maize along with other social and economic dislocations are negatively impacting community social institutions and promoting migration to urban areas and the U.S. The outcome is a declining capacity to maintain the traditional forms of cultivation and propagation of a diversity of landraces (Nadal 2000: 89-90). Additionally, vertical integration of the agricultural sector, particularly in the U.S. has resulted in a reliance on fewer crops. If a widespread disease or pathogen adversely impacts one of those species, then the genetic diversity of centers of origin will be particularly important for developing new strains of disease resistant crops (CEC 2002: 16-7).

[121] In the US, farmers harvesting Bt maize are required to plant at least 20% of the total area with non-Bt maize as a measure to prevent development of Bt resistance in insects and pests.

ecosystem. The case of monarch butterflies dying from eating milkweed covered with Bt pollen is perhaps the most notable and controversial example (Alvarez-Buylla 2002: 5-6).[122]

The ultimate results of the viability of a transgene over time depend on natural factors, most especially natural selection, as well as on human management practices in the cultivation of different maize varieties. While the actual incidence of any of these negative characteristics may be minimal, the potential for their occurrence is of much greater weight given that Mexico is a center of origin for maize and that traditional landraces are important for agricultural diversity and ensuring world food security.

2.3.4 Legislative and Regulatory Context

2.3.4.1 Mexico

An analysis of the import and planting of GM maize must distinguish between GM imports for consumption and for planting. In 1998, Mexico enacted a ban on planting GM maize within the country. Subsequent to that, in the first half of 2001, Semarnat introduced a directive making the unauthorized release of GMOs into the environment a crime punishable by fines or jail sentences. Thus, import for consumption was allowable, while introduction into the environment was prohibited. Without sufficient guidance or labeling to indicate that imports of U.S. maize contained GMOs, there was no effective way for Mexican authorities to prevent the sowing of such seed as sold through government programs and stores. Thus failure to label such maize as containing GMOs or as being solely for consumption most probably led to its introduction into local field crops and thereby incidences of genetic contamination.[123]

Upon release of the findings by Quist and Chapela, the Mexican Senate passed an amendment reinforcing liability for breaches of the directive (Hodgson May 2002: 416-7). On 4 December 2001, the Mexican Senate voted to advise Sagarpa to stop importing GM maize from the US, to undertake a comprehensive study of the scope of contamination and to develop a remediation plan. Despite the resolution Sagarpa has continued allowing imports of U.S. maize.

Beyond the general legislation outlined above on the regulation of invasive species in Mexico, more specific legislation relating to GMOs includes:[124]

- **Federal Law on Plant Health (*Ley Federal de Sanidad Vegetal*, 1994):** Article 43 requires that the application, handling and use of transgenic material for experimental purposes requires receipt of a phytosanitary certificate from SAGARPA.

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[122] There has been significant scientific debate about the impacts of Bt pollen on the monarch butterfly. A review of Bt's use by the American Academy of Microbiology notes that most varieties of Bt corn do not have an impact in the field (as opposed to under laboratory conditions) on the monarch butterfly. However, Event 176 Bt corn was found to lead to a 2% mortality rate (American Academy of Microbiology 2002: 9).

[123] Given that no regulations specifically limited the import of maize containing GMOs intended for consumption, there is no need to look specifically at the Mexican inspection process.

[124] For a general summary of applicable legislation see CIBIOGEM 2002.

- **Law on the Production, Certification and Sale of Seeds (*Ley Sobre Produccion, Certificacion y Comercio de Semillas*, 1991):** Article 5 requires that use of transgenic material of high risk be approved by SAGARPA based on a scientifically validated technical opinion. Non-approved uses are subject to a fine from 1,000 to 10,000 times the daily wage.

- **Law on Sustainable Rural Development (*Ley de Desarrollo Rural Sustentable*, 1999):** Article 39 states that SAGARPA will promote and regulate the investigation, handling and use of materials resulting from biotechnology in regard for ensuring biosafety and health concerns. Further, Article 93 states that policy goals for the application of GMOs will be to: reduce risks for production and public health; increase farming productivity; and facilitate national and international commercialization of such products. In this regard, actions and programs should avoid the entrance of "plagues" and non-endemic diseases in the country. Finally, Article 99 states that further mechanisms and instruments related to the production, import, mobilization, propagation, liberation, consumption and use of GMOs, products and by-products should be developed to ensure biosafety and public health.

- **NOM-056-FITO-1995:** These regulations address the phytosanitary requirements for the movement, important and establishment of field tests of GMOs.

- **Federal Penal Code:** Article 420 *ter*. (2002) establishes prison sentences from one to nine years and fines of 300 to 3,000 times the daily wage for introducing, transporting, storing or releasing a GMO that alters or can negatively alter the components, structure or operation of natural ecosystems.

Finally, the Mexican government is in the process of developing a new law on the biosafety of GMOs. Two versions are being considered, one in the Chamber of Senators and the other in the Chamber of Deputies. The Senate bill is designed to establish administrative procedures to regulate the confined use, experimental release, release through pilot projects, commercial release, and the trade and import of GMOs, to prevent, avoid, or reduce the possible risks that these activities could cause to human health, the environment and/or biodiversity.[125] The competent national authorities for implementing the legislation would be SEMARNAT, SAGARPA and the Secretary of Health (*Secretariat de Salud* – SSA). It generally seeks to implement the requirements of the CBD's Cartagena Protocol on Biosafety, which establishes an advance informed agreement procedure detailing the use of risk assessments in granting permission to the import of LMOs.

Under the proposed law, GMOs for experimental release and commercialization would require a permit (granted by SAGARPA and reviewed by SEMARNAT) based on

[125] The Senate bill builds on other bills proposed in the Chamber of Deputies, including those presented by: the Green Ecological Party of Mexico (PVEM), the National Action Party (PAN), the Institutional Revolutionary Party (PRI) and the Democratic Revolutionary Party (PRD).

a risk assessment. Additionally, GMOs intended for human consumption, would require a public health authorization from the SSA. For other categories of GMOs, producers/importers must provide notification of how any risks will be controlled and confined. The bill's scope includes not just animal, plant and aquatic health, but also direct or indirect use and human consumption, while also requiring follow-up monitoring of GMOs released into the environment. The bill also calls for a listing and authorization process for imported GMOs and includes an article on corrective measures in the event of an imminent risk that a GMO may cause damage or adverse effects to human health or biodiversity.[126] The bill is criticized for failing to: require labeling of GM foods, prohibit GM crops in biosphere reserves and other ecological sensitive areas, and obligate companies to pay for clean up and damages should GM crops escape into the wild (Tegel 2003: 9). Finally, a new regulatory norm is being developed by Semarnat and Sagarpa (NOM-FITO/ECOL-2002) that would specifically permit commercial cultivation of GM crops (Tegel 2003: 1).

2.3.4.2 Canada

Responsibility for regulating products of biotechnology in Canada is generally overseen by the Canadian Food Inspection Agency and its Plant Biosafety Office. These offices oversee plants with novel traits, importation of plants and plant material, animal health, feeds, fertilizers, veterinary biologics and food labeling. Additionally, Health Canada, Environment Canada, Agriculture and Agri-food Canada and other federal agencies also play a role in addressing the respective health, environmental and agricultural aspects of biotechnology. Finally, the Canadian Biotechnology Advisory Council oversees general issues regarding development of policies, regulations and technology, and reports to the Biotechnology Ministerial Coordinating Committee (comprised of ministers of agriculture and agri-food, health, environment, natural resources, fisheries and oceans, and international affairs).[127]

2.3.4.3 U.S.

In the U.S., if a GM crop passes tests within field trials governed by the USDA (more), the subsequent monitoring and surveillance by APHIS is not required to further identify traits of invasiveness. Additionally, there is no requirement on producers of GM seed and propagules to monitor their plantings. However, the EPA requires monitoring of field trials and commercial harvests of Bt crops to assess Bt resistance in pest populations.[128] Regarding biotechnology regulation and commercialization, three agencies share authority:

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[126] See "Proposed Bill on the Biosafety of Genetically Modified Organisms," submitted to the Secretaries of the Mexican Senate. Note: a full discussion of the biosafety regulations of the three NAFTA countries is beyond the scope of this paper. Particular attention has focused on Mexico given its designation as a center of origin and diversity for maize.

[127] For information on the Canadian Biotechnology Advisory Council, see <http://www.cbac-cccb.ca/english/mandate.aro>. For information on regulatory approval processes, see <http://www.inspection.gc.ca/english/ppc/biotech/gen/approvale.shtml>.

[128] Within the US, there are bans on planting Bt crops in Hawaii, southern Florida, Puerto Rico and the US Virgin Islands given environmental concerns. Additionally, to prevent gene flow and transgenic contamination, the EPA also prohibits growing GM cotton in areas of the US where wild relatives are found (National Plant Board 1999).

- US Department of Agriculture: plant pests, plants and veterinary biologics;
- Environmental Protection Agency: microbial/plant pesticides, new uses of existing pesticides and novel microorganisms; and
- Food and Drug Administration: food, feed, food additives, veterinary drugs, human drugs and medical devices.[129]

2.3.5 Levels of Trade

The U.S. is the world's largest producer and exporter of maize, including transgenic varieties. In 2002, estimates were that GM maize was cultivated on about one-third of the area devoted to maize production.[130] Over 90% of these maize exports are shipped to Latin America, and overall U.S. production constitutes approximately 75% of Mexican agricultural imports (Vaughan 2002: 7). With the intermingling of GM and non-GM maize in U.S. exports, percentages of GM crops can reach 25-33% of the overall mix. While U.S. levels of production and exports have remained relatively steady over the last decade, Mexican imports of maize have grown significantly since NAFTA's entry into force. This increase coincides with a decision by the Mexican government not to apply tariffs to U.S. maize imports (as permitted under NAFTA) and the related drop in maize prices by over 50% during the 1995-2000 period (Nadal 2001: 5).

In Mexico, maize cultivation entails the largest area of land, and is second in overall gross production volume. Mexico is a major importer of maize from the U.S. accounting for approximately one-fourth of U.S. maize exports, second only to Japan. In contrast to many other countries, the majority of such imports are intended for human consumption.[131] As mentioned above, in 1998 Mexico imposed a moratorium on the planting of transgenic maize, which primarily applied to commercializing existing GM varieties and to applications for new research (CIMMYT October 2001).

Tables 4a-4c. Maize Production and Trade in North America

Table 4a. Production of Maize (1,000 tonnes)

	92/93	**93/94**	**94/95**	**95/96**	**96/97**	**97/98**	**98/99**	**99/00**	**00/01**
U.S.	240,719	160,954	256,621	187,305	234,518	233,864	247,882	239,719	247,407

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[129] For information on US regulatory oversight in biotechnology, see <http://www.aphis.usda.gov/biotech/OECD/usregs.htm>. For information on permitting, notification and deregulation of products derived from agricultural biotechnology, see >http://www.aphis.usda.gov/ppq/biotech/>.

[130] In 2000, the US farmed approximately 80 million acres of corn, 25% of which was genetically modified. In 2001, of 76 million acres, 26% was genetically modified. Finally, in 2002, of almost 80 million acres, 34% was genetically modified. During this period, GM varieties of Bt maize generally comprised two-thirds of the acreage devoted to GM maize (National Agriculture Statistics Service, *Acreage* reports for 2000, 2001 and 2002, available at <http://usda.mannlib.cornell.edu/reports/nassr/field/pcp-bba>).

[131] Over the period from 1995-97 for which data is available for Mexico, 58% of maize was used for human consumption and 25% for animal feed. By comparison, over the same period, only 2% was used for human consumption in the U.S. and 1% in Canada, whereas 76% was used for animal feed in the U.S. and 78% in Canada (Pinghali 2001: 48-53).
Under NAFTA, corn was one commodity included under a special system of tariff rates for Mexico to be reduced over a fifteen year period. However, since 1994, Mexico has maintained no or minimal tariffs (1%) on corn imports, ostensibly to keep food prices for products such as tortillas low. For a more detailed discussion of maize and tariff rates under NAFTA (CEC 1999: 107).

Mexico	18,631	19,141	17,005	16,000	18,922	16,934	17,788	19,000	19,000
Canada	4,883	6,501	7,043	7,271	7,380	7,180	8,952	9,096	10,200

Source: USDA–FAS

Table 4b. Exports of Maize (1,000 tonnes)

	92/93	**93/94**	**94/95**	**95/96**	**96/97**	**97/98**	**98/99**	**99/00**	**00/01**
U.S.	41,766	33,148	58,645	52,500	46,633	37,697	51,886	46,500	49,500

Source: USDA–FAS

Table 4c. Imports of Maize (1,000 tonnes)

	92/93	**93/94**	**94/95**	**95/96**	**96/97**	**97/98**	**98/99**	**99/00**	**00/01**
U.S.	166	519	245	385	285	126	388	325	325
Mexico	396	1,691	3,166	6,400	3,141	4,376	5,615	4,600	5,000
Canada	1,190	585	1,108	650	879	1,418	903	800	500

Source: USDA–FAS

2.3.6 Recommendations

- Clearly label and provide necessary documentation (e.g., contents, intended use, genetic information, and safety requirements) for GM crops, seeds or other propagative material in local languages and particularly for centers of origin or diversity.

- Require on-going monitoring for the introduction of GMOs into environmentally sensitive areas (e.g., centers of origin/diversity, open net-pen aquaculture).

- Increase research on the "invasiveness" of specific GM crops, animals and by-products prior to field testing and commercialization.

- Develop policy and regulatory tools that can address both "natural" and GM invasives.

- Adopt the necessary SPS standards to protect Mexican cultivars from further contamination, such as a ban on the import of unprocessed GM maize.

- Ratify and implement the Cartagena Protocol on Biosafety.

3.0 General Recommendations

The case studies provide a wealth of information particular to three particular pathways for invasion, each of which has been addressed more specifically by recommendations in their respective sections. Expanding beyond the case studies to look at the regulation of invasive species in the context of agriculture and trade more generally, it is possible to make a number of recommendations pertinent to the state, regional and international levels.

3.1 Domestic action with NAFTA Parties

- Change perspective from increasing trade while dealing with invasives to addressing invasives while allowing trade. Given the significant costs associated with spread and eradication of invasive alien species, addressing invasive alien species issues should be embraced as a prerequisite – not just an afterthought – to increased trade.

- Institute aggressive and the best early detection systems possible. Experts concur that preventing introduction and establishment of invasive species is much less costly and more effective than eradication efforts. NAFTA countries should work together to fund scientists specifically to look for infestations of invasive species. NAFTA countries should actively recruit information from the public about potential infestations and should facilitate the public's ability to submit this information.

- Require documentation and information on country of origin for specified materials that serve as pathways in cargo manifests to facilitate inspections at ports of entry.

- Prioritize inspection rates for cargo harboring known pathways for the introduction of invasive species.

- Minimize dependence on inspection by ensuring that those responsible for the movement of invasive species are motivated to reduce risks they pose of introduction of invasive alien species. One option is to consider user fees tied to risk (see Perrault and Muffett, 2002).

3.2 Regional action among NAFTA Parties

- Recognize and respond to the significance of the threat posed by intracontinental movement of invasive species. As global trade and regional trade increase, the risk that intracontinental trade will spread invasives from one NAFTA country to another increases – as does the need to respond to the risk.

- Recognize and respond to the need to build technical and institutional capacities among North American countries. Because of increasing opportunities for human-mediated spread of invasive alien species as well as opportunities for "natural spread" of invasives among North American countries, the effectiveness of efforts of any one NAFTA country to protect itself will necessarily be tied to efforts of the other NAFTA countries. To protect their mutual interests, NAFTA countries should seek to facilitate technology transfers and information exchange. Additionally, each country should ensure the others have the financial, institutional, technical and scientific capacity to prevent introduction and spread of invasives.

- Complete the development of a North American strategy for invasive alien species, based on a pathway approach. Such a strategy should not rely on port of entry inspection approaches, but should investigate measures for applying sanitary measures and mitigation efforts at the point of origin of the potential invasive and its pathway. Due to the dependence each NAFTA country has on other NAFTA countries for preventing the introduction and spread of invasives, and the need to ensure an effective and efficient response to the problem, the NAFTA countries should develop a joint strategy for preventing the introduction and movement of invasive species.

- Harmonize national regulatory systems and perimeter requirements, such that invasives potentially arriving in one country where there is little risk of invasion are not transported to another country where they are. Regionalization of regulatory controls should not provide loopholes for invasive species that are not common to all countries of the region.

- Participate in development of regional standards. Regional organizations, such as the CEC, are uniquely situated to inform regional environmental efforts. Greater participation by the CEC and other regional environmental organizations could strengthen regional and international standards related to activities to address invasive species.

- Develop common standards for high-risk pathways, and where appropriate seek to expand them to the international level.

- Operationalize, harmonize and expand IABIN/I3N and other Internet-based datasets, which are accessible to customs and inspection agencies, agricultural officials, research institutions and academia, industry and civil society. Greater access to information and data related to invasive species will almost certainly facilitate efforts to address invasives-related problems. Currently, available information is often incomplete, difficult to access and, in some cases, contradictory.

- Harmonize reporting of detailed data on sectoral trade according to a single classification system, such as the NAICS or the international HS Code, and make data more widely available to researchers and the public. While a great deal of information on trade by and among NAFTA parties is currently available, inconsistencies in the classification system employed and differences in the specificity with which data are reported make comparison and cross-border analysis difficult or impossible.

- Ensure that existing and future bilateral and regional free trade agreements provide sufficient leeway to develop sanitary, phytosanitary and zoosanitary measures necessary to prevent the introduction of invasive species, including through the use of a pathway approach.

3.3 Cooperative Action within the International Community

- Encourage use of and tolerance for pathway approaches to preventing the introduction of invasive species within NAPPO and other regional plant protection organizations, and the IPPC and SPS Agreements.

- Develop appropriate standards and phytosanitary measures to protect centers of origin and diversity and other ecologically sensitive areas.

- Examine the expansion of pre-clearance activities and regions, as well as pest free areas of production.

- Consider development of more stringent national regulations under the SPS Agreement and GATT Article XX on exceptions to trade rules to protect human, animal or plant life.

- Review the legal and institutional gap analysis underway within the CBD process, and encourage the development of mechanisms to address existing shortcomings with other relevant international institutions (e.g., IPPC, OIE, WTO Committee on Trade and Environment, and the UN Food and Agricultural Organization).

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